Drinking Water Contaminants: Maternal and Fetal Health Risks

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ABSTRACT

Contamination of drinking water and associated health risks is becoming a serious concern worldwide. It is being increasingly recognized that the impact of water contaminants on pregnant women can be dangerous as it exposes both the mother and fetus at risk. The presence of microorganisms including bacteria, virus, and parasites, chemicals, and radioactive substances in drinking water can cause serious complications in pregnant women such as preterm delivery, miscarriage, and still birth. Fetal complications include small for gestational age, intrauterine growth retardation, congenital anomalies like oral clefts, neural tube defects, and in severe cases, fetal death. To address this issue, there is a need to collect information and a database to relate contaminated water consumption to high risk pregnancy. This could be a challenging task since in the presence of several contaminants it becomes difficult to identify which contaminant is associated with a particular adverse pregnancy outcome. Nevertheless, investigations must be carried out to gather information about the exposure toward a particular contaminant during pregnancy. Furthermore, sources of drinking water should be regularly examined to assess the presence of microbes and toxic levels of pollutants. There is also a need to conduct awareness programs among women on a regular basis, emphasizing on the health risks associated with drinking contaminated water during pregnancy.

Keywords: drinking water contaminants, pregnancy, miscarriage, intrauterine growth retardation, still birth, birth defects.

1. INTRODUCTION

Contamination of drinking water by microbial pathogens, chemicals, and radiation is a major issue affecting health of a large group of population. The problem is of key concern if it affects a woman during pregnancy, because it places the well-being of both mother and unborn child under jeopardy. A group of scientists from the Harvard School of Public Health and Center for Disease Control have reported that out of the 87 chemicals measured in the mother–child pairs, nearly all were found to have crossed the placental barrier and were present in the fetus (Needham et al., 2011). Some of the chemical contaminants being potential teratogens, serious congenital abnormalities may occur in the fetus, affecting its well-being in later life. In order to take adequate preventive measures and also for crisis management in pregnant women exposed to water-borne diseases, it is important to identify the major drinking water contaminants and understand their adverse effects on the mother and fetus.

2. EFFECT OF DRINKING WATER CONTAMINANTS ON MATERNAL AND FETAL HEALTH

2.1 Bacterial diseases

Escherichia coli (E. coli) is usually a commensal bacterium that lives in the gut. Virulent strains of E. coli can contaminate surface and ground water sources (Chen et al., 2011; Coleman et al., 2013; Ozgumus, Celik-Sevim, Alpay-Karaoglu, Sandalli, & Sevim, 2007). Pregnant women with E. coli infection can be easily dehydrated. Pyelonephritis is a serious condition which can be life threatening. In rare cases, E. coli infection can lead to severe bleeding and cause miscarriage or preterm delivery (Ovalle & Levancini, 2001). Neonatal meningitis is a serious disease with high mortality and morbidity caused by E. coli infection (Vale, Morais, Resende, & Taborda, 2013).

The bacterium, Listeria monocytogenes, has been isolated from the river Ganges in Varanasi, India (Soni, Singh, Singh, & Dubey, 2013). During pregnancy, healthy women are more susceptible toward listeriosis (Janakiraman, 2008). This can lead to preterm delivery, miscarriage, chorioamnionitis, and maternal and neonatal sepsis (Mylonakis, Paliou, Hohmann, Calderwood, & Wing, 2002). Fetal and neonatal infections have overall mortality rate of 21%, which is comparatively larger than maternal mortality rate (Schwarze, Bauermeister, Ortel, & Wichmann, 1989). In the United States, ~19% of all death in pregnancy during the second or the third trimester is attributed toward this disease (Scallan et al., 2011). The treatability of the condition implies the importance of early detection of the disease.

Shigella, an organism frequently found in human waste polluted water follows oral transmission pathway. Shigellosis, also known as bacillary dysentery, may lead to premature rupture of membranes during pregnancy (Rebarber, Star Hampton, Lewis, & Bender, 2002).
Salmonella may be found in water bodies polluted with the fecal materials of infected people or animals. Salmonellosis, an infection with Salmonella, can cause septicemia in pregnancy and is highly lethal to the fetus or newborn, compared to mother (Schloesser, Schaefer, & Groll, 2004).

2.2 Viral infections

Hepatitis E virus (HEV) is a virus that spreads via fecal contamination of water supplies. HEV genotype 1 is associated with disease outbreak in children and pregnant women. It is a mild-to-moderate disease in severity in pregnancy. The rate of mortality may climb up to 20% (Purcell, 1994). Every year there are 20 million hepatitis E infection and 5,700 hepatitis E-related deaths worldwide (Aggarwal, 2010). The high mortality rate in pregnancy is thought to be secondary to the associated hormonal (estrogen and progesterone) changes during pregnancy and consequent immunological changes (Navaneethan, Al Mohajer, & Shata, 2008). It may lead to fulminant hepatic failure in many patients and the mortality of disease can be controlled using an effective vaccine (Labrique et al., 2012).

Severe acute respiratory syndrome (SARS) is a respiratory viral disease of zoonotic origin (Bartram & Carr, 2004). SARS infection during pregnancy is associated with incidences of spontaneous miscarriage, preterm delivery, and intrauterine growth retardation (IUGR). In a study conducted on pregnant women with SARS ~6 months in Hong Kong, three deaths occurred out of 12 patients and four women had first trimester spontaneous miscarriage (Wong et al., 2004).

2.3 Parasitic diseases

Ascaris lumbricoides, the giant roundworm present in humans, is another most common water-borne pathogen affecting pregnancy. This infection is attributed to agriculture and unhygienic practices (Pham-Duc et al., 2013) and is reported to cause biliary ascariasis in pregnant women (Shah, Robanni, Khan, Zargar, & Javid, 2005). Physiological and anatomical changes occurring in pregnancy may attenuate infection due to biliary ascariasis (Khuroo et al., 1992).

Infection with Giardia can occur and be passed on via the consumption of Giardia cysts in contaminated water. Giardiasis can cause diarrhea, fluid, and electrolyte imbalance, malabsorption thereby leading to miscarriage and maternal complications (Lengerich, Addiss, & Juranek, 1994).

Toxoplasmosis is a parasitic disease caused by the protozoan Toxoplasma gondii. Cats shed millions of oocysts in their feces which can contaminate drinking water. If the transmission occurs near to conception the risk of infection is more to fetus and may lead to abortion (Roman, Zamir, Rilikis, & Ben-David, 2006). The infection can be transmitted from mother to child via placenta, and it affects mainly the eyes and the nervous system of the fetus. The infection can progress to behavioral abnormalities, hearing loss, visual impairment, and mental retardation in some cases (Stray-Pedersen, 1993). It may also lead to cardiac abnormalities in newborn (Paquet & Yudin, 2013).

Malaria is a mosquito-borne infectious disease caused by the parasitic protozoan Plasmodium. It is endemic in ~90 countries and is responsible for 1–3 million deaths per year. Anopheles mosquito, the major vector of malaria, prefers clean water as its breeding place (Gunathilaka et al., 2013). It is, therefore, very important that water stored for drinking purposes should not be left uncovered. Malaria is a threat to pregnant women. Pregnant women have lower acquired immunity, and malarial infection is more likely to evolve toward clinical disease. Intrauterine transmission of malaria parasite from mother to fetus frequently occurs depending upon efficiency of placenta in blocking the parasite. Malaria increases risk of low birth weight and intrauterine growth retardation and is a cause of infant and maternal mortality (Steketee et al., 1996; Sullivan et al., 1999; Verhoeff et al., 2001).

3. CHEMICAL TOXICANTS

Increase in chemical contamination of drinking water as a result of growing industrialization is a matter of major concern. The adverse effect of various contaminants present in drinking water on pregnancy has generated considerable research interest. Walker, Rattigan, and Canterino (2011) have studied the effect of copper toxicity in pregnant women. Excessive copper levels are linked with IUGR, preeclampsia, and neurological diseases. The studies also suggest that their accumulation in tissues can contribute to cardiac dysfunction, liver cirrhosis, pancreatic dysfunction, and neurological abnormalities (Roberts & Schilsky, 2008).

Exposure to chromium can also induce complications during pregnancy and child birth (Wilbur, Ingerman, Citra, Osier, & Wohlers, 2000). Developmental defects including postimplantation losses, resorption, reduced fetal weight, and malformations are associated with high chromium levels in drinking water.

Contamination of water with Arsenic is another regional and global issue. Among other countries, India and Bangladesh are the top two countries with a higher percentage of negative impact due to
Arsenic. In Bangladesh, a key pathway of exposure is the consumption of Arsenic-contaminated water. The first report of undesirable health issues related to pregnancy in Bangladesh goes back to 2001 (Milton et al., 2003). Other research involved two-hundred-two mothers relating “pregnancy outcomes” to “infant mortality” in the state of “West Bengal” India (Von Ehrenstein et al., 2006; Mazundar, 2008). Increased level of arsenic (≥ 50 mg/L) during pregnancy was found to be linked with higher risk of still birth and abortion (Milton et al., 2005). Cadmium, another trace metal, is considered to be more teratogenic after implantation. It is suggested that cadmium and arsenic influence fetal development in a sex-dependent manner (Kippler et al., 2012).

The lead in a mother’s blood can cross the placenta and show up in the umbilical cord. Such lead contamination in a mother’s blood is associated with multiple diseases, including IUGR, birth defects, preterm delivery, fetal neurotoxicity, and skeletal abnormalities (Weizsaecker, 2003). A lady who is not pregnant at the time of exposure can easily pass lead onto the fetus, because 90% of the lead stored in the bone is released into the blood stream after several years (Gilbert-Barness, 2010). Transfer of lead from a mother’s bone could occur during pregnancy, and it further increases the probability of lead toxicity in the fetus (Weizsaecker, 2003; Riess & Halm, 2007). Various studies have indicated linkage of the mother’s exposure to lead via contaminated drinking water with the abnormalities of the child (Weizsaecker, 2003). Another heavy metal, mercury, can cross placenta and affect the development of brain (Gundacker & Hengstschlager, 2012).

Nitrate toxicity is associated with in vivo conversion of nitrate to nitrite after ingestion. Nitrogen fertilizers are generally used to enrich soils since nitrates are a critical source of nitrogen for plants. Rain, irrigation, and other surface water systems tend to transport the nitrates through the soil to the ground water. Another contributory factor toward nitrate contamination of drinking water is the human and animal wastes. Maternal intake of nitrates ≥5 mg/d is reported to be associated with increased tendency of newborn to have neural tube defects, oral clefts, congenital cardiac defects, and limb deficiencies (Breder et al., 2013; Cedergren, Selbing, Lofman, & Kallen, 2002; Croen, Todoroff, & Shaw, 2001).

The presence of pesticide residues in drinking water poses to be a major threat to maternal and fetal well-being. Increasing amount of total serum dichlorodiphenyltrichloroethane (DDT) concentration is reported to increase the chance of early pregnancy losses (Venners et al., 2005). Polycyclic aromatic hydrocarbons (PAHs) are widespread pollutants commonly found in air, food, and drinking water. Compromised fetal development following transplacental exposure to PAH is evidenced (Bove, Shim, & Zeitz, 2002). Trihalomethanes (THMs) are formed as a byproduct when water is cleaned using chlorine. Various studies prove that intake of THMs during pregnancy can lead to cardiac defects, small for gestational age, low birth weight, preterm delivery, spontaneous abortion, oral clefts, and neural tube defects.

It is well established that consumption of water with a high level of radioactive toxicants by pregnant women exposes them at an increased risk of spontaneous abortion and giving birth to babies with congenital defects. Daily intake of uranium in food and water varies from ~1–5 mg/d in uncontaminated regions to 13–18 per day or more in uranium-mining areas (Taylor & Taylor, 1997). Reduced growth of the offspring and fetal toxicity including teratogenicity has been observed following uranium exposure in animal experiments (Domingo, 2001). Radon is the decay product of radium. A study conducted by Schieve et al. (1997) has shown that radium exposure during pregnancy can cause still births.

4. CHALLENGES AHEAD
An excellent review by Bove et al. (2002) mentions that a majority of the states in the U.S. keep records of supplied water samples as per the applicable drinking water law—both federal and state. Moreover, information related to birth and associated parent-related risk attributes are kept at the state level. These databases are used to study links between drinking water contamination and adverse birth outcomes. Unfortunately, such a database is yet to be developed and made available in India.

5. CONCLUSION
Studies indicate linkage between contaminated water consumption and high risk pregnancy. Though challenging, in the presence of multiple contaminants, there is a need to identify which contaminant in the drinking water system is associated with a particular adverse pregnancy outcome. Future studies should be directed toward individual exposure assessments in both the rural and urban areas. Surveys must be carried out to gather information about the exposure toward a particular contaminant particularly during pregnancy. A database should be maintained for children born with congenital defects, and a proper investigation should be done on the water supply system in that community. Sources of water in the community should...
be routinely examined to assess the level of heavy metals and the presence of microorganisms. Finally, awareness programs to prevent the spread of waterborne diseases may be conducted among women in rural areas, wherein illiteracy and lack of knowledge are a major concern.

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