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Maternal and infant exposure to environmental phenols as measured in multiple biological matrices

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HIGHLIGHTS

- BPA and triclosan were measured in maternal and infant biospecimens
- Triclosan was detected in over 80% of maternal urines and meconium
- BPA was detected in over 90% of maternal urines and 40% of infant urines

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ABSTRACT

Background: Results of recent national surveys have shown the high prevalence of exposure to bisphenol A (BPA) and triclosan (TCS) among the general population; however biomonitoring data for pregnant women and infants are limited.
Methods: Women (n = 80) were recruited from early prenatal clinics and asked to collect urine samples multiple times during pregnancy and once 2–3 months post-partum. Samples of infant urine and meconium as well as breast milk and infant formula were also collected. Biospecimens were analyzed by GC–MS/MS for BPA, TCS and triclocarban (TCC).
Results: Triclosan was detected in over 80% of the maternal urines (geometric mean (GM): 21.61 μg/L), 60% of the infant urines (GM: 2.8 μg/L), 46% of the breast milk and 80% of the meconium samples. Triclocarban was rarely detected in any of the biospecimens. Median total BPA concentrations were 1.21 and 0.24 μg/L in maternal and infant urines, respectively. Free BPA was detected in only 11% of infant urine samples. The meconium of female infants had significantly higher concentrations of total BPA and TCS than those of males, while no differences were observed in infant urine concentrations by sex.
Conclusions: We found widespread exposure among pregnant women and infants to environmental phenols, with large inter-individual variability in exposure to triclosan. These data will contribute to the risk assessment of these chemicals, especially in susceptible sub-populations.

1. Introduction

Environmental phenols such as bisphenol A (BPA), triclosan (TCS) and triclocarban (TCC) are non-persistent ubiquitous chemicals that are primarily excreted in urine. BPA and TCS are commonly detected in urine samples from national surveys in Canada and the United

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States, whereas TCC exposure is less prevalent (Health Canada, 2013; CDC, 2013; Ye et al., 2011a).

Triclosan is used to preserve materials such as textiles, leather, paper, plastic and rubber and as an anti-bacterial and anti-fungal agent in a number of cosmetics and personal care consumer products including non-prescription drugs and natural health products (Health Canada and Environment Canada, 2012). The US Department of Health and Human Services lists a number of household products in their database which contain TCS or TCC (http://householdproducts.nlm.nih.gov/index.htm, accessed February 19, 2014). TCS can be found in antibacterial hand soaps, dishwashing liquid, toothpaste, shaving gel, antiperspirant, deodorant, face and body wash, hand lotion, lipcolor, and antibacterial dog shampoo. Self-reported use of personal care products in adolescents has been reported to be a significant determinant of urinary TCS concentrations (Den Hond et al., 2013).

TCC is also used in a number of consumer products as an antibacterial agent in the US; however, published data to date indicates that the number of products containing TCC is far fewer than those containing TCS. Unlike in the US, no drug products are marketed in Canada with triclocarban as an active medicinal ingredient nor is it an ingredient in any licensed natural health product (http://webprod3.hc-sc.gc.ca/lnhpd-bdpsnh/start-debuter.do?lang=eng; http://webprod5.hc-sc.gc.ca/dpd-bdpp/index-eng.jsp, accessed August 20, 2013).

BPA is an industrial chemical that has been used in the manufacture of polycarbonate plastics and in hardeners, paperboard packaging, adhesives, custom color powder coatings and as a curing agent for resurfacing concrete, and is also found in epoxy resins used to line metal food and beverage cans (Environment Canada and Health Canada, 2008). Approximately two-thirds of the intake of BPA in adults is estimated to come from dietary sources, with the balance from other routes (Christensen et al., 2013).

Only two epidemiologic studies have explored potential health effects of prenatal exposure to TCS and reported no significant impact on birth weight, length or head circumference (Wolff et al., 2008; Philippat et al., 2012); however one of these studies did report that male infants were significantly shorter when prenatally exposed to higher levels of TCS (Wolff et al., 2008).

Epidemiologic studies on the effects of prenatal exposure to BPA on pregnancy outcomes are limited, with often no significant effects observed or in the case of total BPA and fetal growth, conflicting results (Lee et al., 2014; Chen et al., 2013; Tang et al., 2013; Snijder et al., 2013; Robledo et al., 2013; Philippat et al., 2012; Cantonwine et al., 2010; Wolff et al., 2008). Similarly some studies have reported no observed effects of prenatal BPA exposure on child behavior (Miodovnik et al., 2011; Yolton et al., 2011) while others found significant effects (Harley et al., 2013a; Perera et al., 2012; Braun et al., 2011a) with support from the toxicological literature for sexually dimorphic phenotypes (Kundakovic et al., 2013; McCaffery et al., 2013; Wolstenholme et al., 2011).

Given the potential for endocrine disruption associated with BPA (Meeker, 2012), triclosan (evidence in rodents with uncertain implications for humans) (Allmyr et al., 2009; Cullinan et al., 2012; Koeppe et al., 2013) and triclocarban (Witorsch and Thomas, 2010), and the paucity of data on early life exposure to these chemicals, a prospective pregnancy study was conducted. As the free phenol is presumed to be more biologically active, we measured both total (free plus conjugated) and free BPA in infant urine, meconium and breast milk.

2. Materials and methods

2.1. Study population

Women in early pregnancy (<20 weeks gestation) were approached at prenatal clinics in Ottawa (Ontario, Canada) between December 2009 and December 2010 and invited to participate in the Plastics and Personal-care Products use in Pregnancy (P4) Study. A poster and pamphlets were also placed in the obstetrical and ultrasound clinics of The Ottawa Hospital and physician offices. Eligibility criteria included ability to consent and to communicate in English or French, age 18 years or older and planning on delivering within the City of Ottawa. Women with major medical conditions such as renal disease, epilepsy, heart disease and cancer or with known fetal abnormalities or major malformations were excluded from the study. In addition, women who were already participating in 2 or more research studies were disqualified. The study was approved by human studies ethics committees at Health Canada and the Ottawa Hospital and all participants signed an informed consent form.

2.2. Data and biospecimen collection

2.2.1. Maternal urine collection

Women who consented to participate were asked to collect every urine void in separate containers over a 24-hour period during early pregnancy (between 6 and 19 weeks), as well as a spot urine void during the 2nd (24–28 weeks) and 3rd (32–36 weeks) trimesters and 2–3 months post-partum (Table 1). During early pregnancy, women were asked to collect and record the dates and times of all urine voids over a 24-hour period on a week-day (T1a) and/or a week-end day (T1b). Women were provided with pre-screened urine cups (polypropylene) and a cooler bag with ice packs. To avoid degradation of the target chemicals, the urine was kept cool (4 °C) during the collection period, mixed well and aliquoted within 36 h of collection and then stored frozen at −80 °C. A research assistant visited the participants' homes to retrieve the urine samples that were collected over the 24-hour period. The spot samples were collected during regularly scheduled clinic visits or at home and women were asked to provide information on the time of the void and the time since last void.

2.2.2. Infant urine collection

Infant urine was collected twice in the early post-natal period using pre-screened newborn urine-bags (U-bags) (Hollister Inc. Libertyville, IL; and Mabis Healthcare, Waukegan, IL) (Table 1). The first infant urine sample was collected either at the hospital, if possible, or at home up to one month after birth (T4).

Prior to collecting infant urine, the genital area was cleansed using only warm water and a washcloth, allowed to air dry and then a U-bag was attached. When at least 5 mL of urine was collected, the sample was transferred from the U-bag into sterile 30 mL Nalgene® containers. The date and time the bag was removed were noted and the urine refrigerated. Within 24 h of collection, the urine was aliquoted and frozen at −80 °C. The maximum length of time the U-bag was left attached to the infant was 4 h. Infant urine was also collected 2–3 months post-partum (T5) during a home visit.

2.2.3. Meconium collection

Pre-screened Mère Hélène® bioliners (Mère Hélène, Quebec Canada) were inserted into the diapers. After the meconium was passed, a wooden spatula was used to transfer the meconium to a 50 mL Sarstedt tube and then refrigerated. The sample was collected on one or more occasions within the first two days after delivery until approximately 10 g was collected. A note was to be made if the diaper was wet with urine and of any lotions, powders, wipes or creams that had been applied to the baby's bottom. The samples were pooled and frozen within 72 h of collection at −20 °C.

2.2.4. Breast milk and/or infant formula

Two to three months post-partum, a sample of breast milk (minimum 20–30 mL) was collected in a 150 mL glass jar. The women were provided with a Medela® (Medela International, Zug, Switzerland) manual breast pump prior to delivery. Alternatively, women could choose to hand express directly into the glass container. Immediately