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Environmental Health Insights

Bisphenol A (BPA) Found in Humans and Water in Three Geographic Regions with Distinctly Different Levels of Economic Development

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ABSTRACT: The suspected endocrine disruptor bisphenol A (BPA) is associated with the manufacture, distribution, and use of epoxy resins and polycarbonate plastics; thus, studies of this compound have focused primarily on urban areas in developed countries. This small study investigating urinary BPA of 109 people was conducted in the urban United States, urban Jamaica, and rural Ghana. Additionally, local drinking and surface water samples were collected and analyzed from areas near study participants. Levels of BPA in both urine and water were comparable among all three sites. Thus, future studies of BPA should consider expanding investigations to rural areas not typically associated with the compound.

KEYWORDS: bisphenol A, water, urine, rural, urban

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Introduction

Although considered common in the environment, the suspected endocrine-disruptor[1–6] bisphenol A (BPA) has been associated with larger urban areas in more developed countries where the manufacture, distribution, and use of epoxy resins and polycarbonate plastics is concentrated.[7–12] Recent studies of more urbanized areas have detected the compound in environmental samples of wastewater treatment effluent,[7,8,10,13] urban runoff,[10] combined sewer overflows,[10] and atmospheric aerosols from the burning of municipal waste.[9] This emphasizes the range of pathways by which BPA may enter the environment, causing a large proportion of the population to be at risk for exposure. Because the release of BPA into the environment has been associated with more urban, industrialized activities in more developed countries, it is thought to be less of a concern for populations in more rural areas of less developed countries. As part of a larger population-based study, the Modeling the Epidemiologic Transition Study (METS)[14] was conducted to investigate epidemiologic determinants of obesity, diabetes, and cardiovascular disease across a number of developed and less developed countries. A small pilot study was conducted to determine if BPA could be detected in a subset of METS study participants and their local water samples. Results of this study may help clarify the role that this potential endocrine disruptor plays in the incidence of targeted diseases throughout the METS participant countries.

Methods

In 2010, samples from 109 participants from three METS sites, including rural Ghana (Nkwantakese), urban Jamaica

(Kingston), and urban United States (Maywood, IL within the Chicago metropolitan area), were analyzed for BPA. Written informed consent was obtained using METS. These study sites were chosen because they represent a wide range of socioeconomic development levels as defined by the United Nations Human Development Index (HDI) 2010 (http://hdr.undp.org/en/statistics/). The selection of study participants and urine collection was in accordance with METS[9] protocols and procedures. Analyses of urine samples were performed by NMS Labs (Willow Grove, PA, USA) using gas chromatography (GC) with detection by mass spectrometry (MS) in the selected ion-monitoring mode. Urinary BPA was standardized to creatinine to account for urine concentration.

To examine nearby drinking and environmental water sources as a potential pathway of BPA exposure,[15–19] a total of 39 (250 mL) water samples were taken from various locations within the study areas. In Maywood, 9 water samples were collected: 3 were drinking water taken from taps within homes, 2 were local river water, and 4 were bottled drinking water. In Kingston, 18 water samples were collected: 6 were drinking water taken from taps within different homes, 8 were taken from local streams and reservoirs (4 each), and 4 were from bottled drinking water. In Ghana, 12 water samples were collected: 10 were taken from local bore-hole water pumps used for drinking water by villagers and 2 were taken from local streams. All samples were collected and processed using materials that were verified by the manufacturer to contain zero BPA, and standards were used to confirm zero contamination. Water samples were analyzed using ultra-high performance liquid chromatography (HPLC) with detection by triple quadruple mass spectrometry. A more detailed description of mass spectrometry analyses can be found in Supplementary File 1.

Results

Urinary BPA was assessed for 109 adults (n = 38, 35, and 36 for the Maywood, Nakwantakese, and Kingston sites, respectively). Participants were 55.3%, 42.9%, and 47.1% male for Maywood, Nkwantakese, and Kingston, respectively, with mean (SD) ages of 31.9 (5.2), 36.7 (6.4), and 34.1 (5.8) years. Of the participants, 35 (92.1%), 26 (74.3%), and 33 (91.7%) showed detectable levels (minimum detection limit = 0.013 ng/mL) of urinary BPA in Maywood, Nkwantakese, and Kingston, respectively (Table 1). The mean (SD) urinary BPA concentration was 2.47 ng/mL (5.0), 2.19 ng/mL (3.7), and 2.11 ng/mL (2.2) for Maywood, Nakwantakese, and Kingston, respectively. The range of detected urinary BPA was 1.17–30.30 ng/mL, 1.06–18.95 ng/mL, and 1.08–8.98 ng/mL for Maywood, Nkwantakese, and Kingston, respectively. BPA was detected in 20 of the 39 water samples analyzed (minimum detection limit = 0.01 ng/mL); 5 of 9 samples from Maywood, 7 of 12 Nkwantakese, and 4 of 14 from Kingston. Table 2 shows the levels of BPA detected in different water samples across the three study sites. In Maywood, BPA was detected in drinking water (1 of 3 samples, 0.01 ng/mL), river water (2 of 2 samples, mean 0.12 ng/mL), and bottled water (2 of 4 samples, 0.003 ng/mL). For Nkwantakese (Ghana), BPA was detected in drinking water (7 of 10 samples, mean 0.008 ng/mL), but not in stream water (0 of 2 samples). In Kingston, BPA was detected in drinking water (2 of 6 samples, mean 0.003 ng/mL), stream and reservoir water (2 of 8 samples, mean 0.016 ng/mL), and bottled water (4 of 4 samples, mean 0.008 ng/mL).

Discussion

Urinary BPA was detected in urine samples of participants living at all three sites examined. A total of 106 of the 109 study participants showed detectable BPA in urine samples analyzed. Twenty of the 39 water samples taken contained detectable levels of BPA. Despite their association with more industrialized areas in developed countries, the levels of compound detected in the urine and water samples from rural Nkwantakese were comparable to those of the much more urbanized cities of Kingston and Maywood. It is possible that some of BPA pollution found in this village may have resulted from industrial and manufacturing activities from the closest city of Kumasi (approximately 25 km away) or from upstream. While the sources of BPA in Ghana and Jamaica were not identified, the use of plastics, epoxies, and insulation (common sources of BPA) is ubiquitous. The fact that BPA was detected in drinking water in all three sites also indicates a potential route of exposure; however, the presence of urinary BPA suggests that food is a likely exposure point as well. The results of this study suggest that even in rural areas of a less developed country, BPA is common and that future studies of the compound should include areas less commonly associated with BPA exposure and pollution.

Table 1. Urinary BPA concentrations.

	N	NUMBER OF PARTICIPANTS WITH UNDETECTABLE BPA (BELOW LOWER LIMIT OF DETECTION, 0.013 NG/ML)	URINARY BPA CONCENTRATION (NG/ML) MEAN (SD)	RANGE OF DETECTED LEVELS OF URINARY BPA (NG/ML)
Maywood, Illinois	38	3	2.47 (5.0)	1.17–30.30
Nakwantakese, Ghana	35	9	2.19 (3.7)	1.06–18.95
Kingston, Jamaica	36	3	2.11 (2.2)	1.08–8.98

Table 2. Water samples tested for BPA.

	% OF SAMPLES WITH DETECTABLE BPA	MEAN OF SAMPLES WITH DETECTABLE LIMITS (NG/ML)	SOURCES
Maywood, Illinois			
Drinking water	33.3	0.011	*Tap water from participants homes*
Stream	100.0	0.119	*Des Plaines River and Silver Stream (tributary) in neighborhood*
Bottled	50.0	0.003	*Commercial bottled water from neighborhood grocery store*
Nakwantakese, Ghana			
Drinking water	70.0	0.009	*Bore-hole water pumps (ground water) used for drinking water*
Streams	0.0	–	*Local, spring-fed streams in/around village; Barekese Reservoir*
Kingston, Jamaica			
Drinking water	33.3	0.003	*Tap water and storage tank water from participants homes*
Stream	25.5	0.016	*Hope River, Constance River, and Mona Reservoir*
Bottled water	100.0	0.008	*Commercial bottled water from neighborhood grocery store*

Author Contributions

Conceived, designed, and performed the experiments: VPK, JPR, RB, RDA, NM, LRD, LV, NCT, TF, AL, GL, KH. Analyzed the data: VPK, GL, KH, JEH, NM, LRD, AL. Wrote the first draft of the manuscript: VPK, JEH. All authors reviewed and approved of the final manuscript.

DISCLOSURES AND ETHICS

As a requirement of publication the authors have provided signed confirmation of their compliance with ethical and legal obligations including but not limited to compliance with ICMJE authorship and competing interests guidelines, that the article is neither under consideration for publication nor published elsewhere, of their compliance with legal and ethical guidelines concerning human and animal research participants (if applicable), and that permission has been obtained for reproduction of any copyrighted material. This article was subject to blind, independent, expert peer review. The reviewers reported no competing interests.

Supplementary Data

Supplementary File 1. More detailed description of UHPLC-MS-MS analysis of BPA in water.

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