

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

Authors: Karalius, Vytas P., Harbison, Justin E., Plange-Rhule, Jacob, Van Breemen, Richard B., Li, Guannan, et al.

Source: Environmental Health Insights, 8(1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/EHI.S13130>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

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

Vytas P. Karalius¹, Justin E. Harbison¹, Jacob Plange-Rhule², Richard B. van Breemen³, Guannan Li³, Ke Huang³, Ramon A. Durazo-Arvizu¹, Nallely Mora¹, Lara R. Dugas¹, Lane Vail⁴, Nancy C. Tuchman⁴, Terrence Forrester⁵ and Amy Luke¹

¹Department of Public Health Sciences, Loyola University Chicago, Chicago, IL, USA. ²Department of Physiology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. ³Center for Botanical Dietary Supplements Research, University of Illinois College of Pharmacy, Chicago, IL, USA. ⁴Institute of Environmental Sustainability, Loyola University Chicago, Chicago, IL, USA. ⁵Tropical Medicine Research Institute, University of the West Indies—Mona, Kingston, Jamaica.

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

CITATION: Karalius et al. Bisphenol A (BPA) Found in Humans and Water in Three Geographic Regions with Distinctly Different Levels of Economic Development. *Environmental Health Insights* 2014;8 1–3 doi: 10.4137/EHI.S13130.

TYPE: Short Report

FUNDING: This study was supported in part by funding from National Institutes of Health (R01 DK 080763) and in part by the Loyola University Chicago President's Inter-campus Collaborative Research Stimulation Award.

COMPETING INTERESTS: Author(s) disclose no potential conflicts of interest.

COPYRIGHT: © the authors, publisher and licensee Libertas Academica Limited. This is an open-access article distributed under the terms of the Creative Commons CC-BY-NC 3.0 License.

CORRESPONDENCE: jharbison@luc.edu

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 METS⁹ 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, Nkwantakese, 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, Nkwantakese, 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
Nkwantakese, 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.

REFERENCES

- Manikkam M, Tracey R, Guerrero-Bosagna C, Skinner MK. Plastics derived endocrine disruptors (BPA, DEHP and DBP) induce epigenetic transgenerational inheritance of obesity, reproductive disease and sperm epimutations. *PLoS One*. 2013;8(1):e55387.
- Ben-Jonathan N, Hugo ER, Brandebourg TD. Effects of bisphenol A on adipokine release from human adipose tissue: Implications for the metabolic syndrome. *Mol Cell Endocrinol*. 2009;304(1–2):49–54.
- Ben-Jonathan N, Steinmetz R. Xenoestrogens: the emerging story of bisphenol a. *Trends Endocrinol Metab*. 1998;9(3):124–8.
- Stahlhut RW, Welshons WV, Swan SH. Bisphenol A data in NHANES suggest longer than expected half-life, substantial nonfood exposure, or both. *Environ Health Perspect*. 2009;117(5):784–9.
- Vom Saal FS, Nagel SC, Coe BL, Angle BM, Taylor JA. The estrogenic endocrine disrupting chemical bisphenol A (BPA) and obesity. *Mol Cell Endocrinol*. 2012;354(1–2):74–84.
- Rubin BS. Bisphenol A: an endocrine disruptor with widespread exposure and multiple effects. *J Steroid Biochem Mol Biol*. 2011;127(1–2):27–34.
- Jackson J, Sutton R. Sources of endocrine-disrupting chemicals in urban wastewater, Oakland, CA. *Sci Total Environ*. 2008;405(1–3):153–60.
- Arditsoglou A, Voutsas D. Partitioning of endocrine disrupting compounds in inland waters and wastewaters discharged into the coastal area of Thessaloniki, Northern Greece. *Environ Sci Pollut Res Int*. 2010;17(3):529–38.
- Fu P, Kawamura K. Ubiquity of bisphenol A in the atmosphere. *Environ Pollut*. 2010;158(10):3138–43.
- Cladière M, Gasperi J, Lorgeoux C, Bonhomme C, Rocher V, Tassin B. Alkylphenolic compounds and bisphenol A contamination within a heavily urbanized area: case study of Paris. *Environ Sci Pollut Res Int*. 2013;20(5):2973–83.
- Félix-Cañedo TE, Durán-Álvarez JC, Jiménez-Cisneros B. The occurrence and distribution of a group of organic micropollutants in Mexico City's water sources. *Sci Total Environ*. 2013;454–5:109–18.
- Wang B, Huang B, Jin W, et al. Occurrence, distribution, and sources of six phenolic endocrine disrupting chemicals in the 22 river estuaries around Dianchi Lake in China. *Environ Sci Pollut Res Int*. 2013;20(5):3185–94.
- Höhne C, Püttmann W. Occurrence and temporal variations of the xenoestrogens bisphenol A, 4-tert-octylphenol, and tech. 4-nonylphenol in two German wastewater treatment plants. *Environ Sci Pollut Res Int*. 2008;15(5):405–16.
- Luke A, Bovet P, Forrester TE, et al. Protocol for the modeling the epidemiologic transition study: a longitudinal observational study of energy balance and change in body weight, diabetes and cardiovascular disease risk. *BMC Public Health*. 2011;11:927.
- Chen HW, Liang CH, Wu ZM, et al. Occurrence and assessment of treatment efficiency of nonylphenol, octylphenol and bisphenol-A in drinking water in Taiwan. *Sci Total Environ*. 2013;449:20–8.
- Colin A, Bach C, Rosin C, Munoz JF, Dauchy X. Is Drinking Water a Major Route of Human Exposure to Alkylphenol and Bisphenol Contaminants in France? *Arch Environ Contam Toxicol*. 2013.
- Fan Z, Hu J, An W, Yang M. Detection and occurrence of chlorinated byproducts of bisphenol a, nonylphenol, and estrogens in drinking water of china: comparison to the parent compounds. *Environ Sci Technol*. 2013;47(19):10841–50.
- Renz L, Volz C, Michanowicz D, et al. A study of parabens and bisphenol A in surface water and fish brain tissue from the Greater Pittsburgh Area. *Ecotoxicology*. 2013;22(4):632–41.
- Shi W, Hu G, Chen S, et al. Occurrence of estrogenic activities in second-grade surface water and ground water in the Yangtze River Delta, China. *Environ Pollut*. 2013;181:31–7.