Human exposures to Bisphenol A alternatives and derivatives with equal or more harmful effects

Recent years have witnessed an exponential interest in the use and research on bisphenol A (BPA). BPA is one of the chemicals ranked very high in the chemicals' list with the highest production volume estimates worldwide. BPA is widely used in polycarbonate plastics and epoxy resins that are components in multifarious consumer and cosmetic products. We can find BPA in several personal care- and household-products used on a daily basis. For example, some examples of BPA containing products that we encounter frequently are food, water and beverage packaging containers, cooking utensils, children toys, teething rings and pacifiers, dental composites and sealants, electrical and electronic equipment, thermal print paper used for receipts, magazines, books etc. Moreover, transformation and degradation of certain consumer products under normal to abnormal storage conditions can release BPA into indoor air, dust and contact surfaces. These results in humans' exposure to BPA from multiple sources and enter human body through oral consumption, dermal and subcutaneous contact, and inhalation. BPA is an endocrine disruptor with well-known hormonal dysfunction effects and linked with health risks of developing metabolic disorders such as obesity and type II diabetes mellitus. Given these alarming findings, regulatory bodies and policies started to focus and enforce restrictions on the manufacturing and use of BPA.

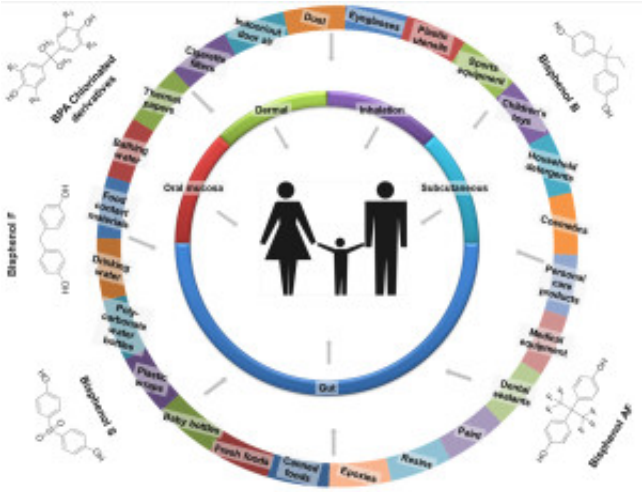

Fig. 1. Proposed exposure sources for BPA alternatives and derivatives, and possible exposure routes in humans.

This opened the doors for BPA alternatives to enter the industrial and consumer markets. BPA structural analogs such as bisphenol F (BPF) and bisphenol S (BPS) are similar in structure to BPA but not the same and hence commercially-labelled as BPA-free promoting the notion among

consumers that these are safer to use compared to BPA. However, their long-term and chronic health impact to humans and sensitive subpopulation groups has not been fully assessed yet. On the other, BPA in consumer products can react with chlorine present as a disinfectant in tap water and/or household cleaning products and solutions resulting in the instantaneous formation of chlorinated derivatives of BPA (ClxBPA). ClxBPA are known for having higher estrogenic-activity compared to the parent BPA, and are linked with alteration and disruption of hormonal and metabolic pathways. Similar reactivity to disinfectant chlorine is anticipated for the structural BPA analogs, but this remains to be experimentally documented. An increasing number of scientific reports dealing with metabolism and toxicity of the above mentioned substances in animal studies can be found. However, very limited information is available on the sources and routes of exposure to these new forms of BPA in human populations (Fig. 1).
Researchers from the Icahn School of Medicine at Mount Sinai (New York, USA), Cyprus International Institute for Environmental and Public Health (Limassol, Cyprus), and University of Groningen (Groningen, Netherlands) reviewed and critically discussed human exposures to BPA alternatives and derivatives. The article reviews all studies that deal with monitoring of chlorinated derivatives and structural analogs of bisphenol A in various human and environmental matrices. The authors presented information on the exposure sources and routes to these chemicals, and metabolism and toxicity outcomes as observed in *in-vitro* and *in-vivo* studies. Further, information on the reported concentrations of these emerging BPA-based chemicals in human body tissues and fluids, and the possible associations with human health effects such as hormonal and metabolic disorders was presented. The article elaborates on current limitations; provide directions for future research and opportunities, and promote research needs for the inclusion of ClxBPA and BPA analogs into human exposure assessment protocols of current and relevant epidemiological studies. This study was supported by the European Structural Funds, and will form the basis for further research to contribute and progress towards the unified goal of the European Human Biomonitoring Initiative that is ready for launch.

Syam S. Andra[1] *and* ***Konstantinos C. Makris***[2]
[1]*Division of Environmental Health, Department of Preventive Medicine, Icahn School of Medicine at Mount Sinai, New York, NY, USA*
[2]*Cyprus International Institute for Environmental and Public Health in association with Harvard School of Public Health, Cyprus University of Technology, Limassol, Cyprus*

Publication

Biomonitoring of human exposures to chlorinated derivatives and structural analogs of bisphenol A.
Andra SS, Charisiadis P, Arora M, van Vliet-Ostaptchouk JV, Makris KC
Environ Int. 2015 Dec