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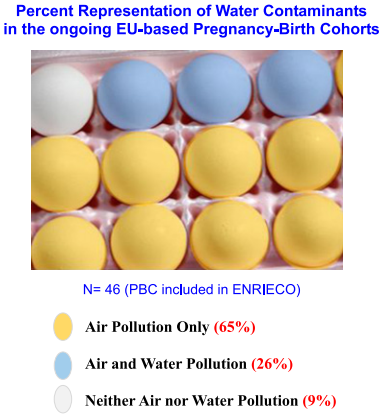
Short Communication

Limited representation of drinking-water contaminants in pregnancy–birth cohorts

Konstantinos C. Makris [a,*], Syam S. Andra [a,b]

[a] Cyprus International Institute for Environmental and Public Health in association with Harvard School of Public Health, Cyprus University of Technology, Limassol, Cyprus
[b] Harvard-Cyprus Program, Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts 02115, United States

GRAPHICAL ABSTRACT



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ABSTRACT

Water contamination and noise have been consistently the least assessed environmental/lifestyle exposures in pregnancy–birth cohorts (PBC). Water quality surveillance data collected during the past decade within urban drinking-water distribution systems call for re-evaluation of water and health issues in the developed world. The objectives of this scientific commentary were to (i) highlight the extent of appraisal of water contamination in exposure assessment studies of PBC, worldwide, and (ii) propose recommendations to increase awareness of emerging water-related risks through their improved representation into PBC study designs in urban centers. Three scientific literature databases (Scopus, PubMed, and Web of Science) were used for a systematic search on worldwide PBC and their publications that considered water contamination and health outcomes. Publicly-available e-databases (ENRIECO, BIRTHCOHORTS, and CHICOS) were also employed for detailed exploration of existing European Union (EU)-based PBC. Out of the 76 PBC identified in the EU territory, only 12 of them incorporated water contamination into their study designs. Among which only 6 PBC published scientific articles that either included data on water contamination and/or water intake estimates. Trihalomethanes but not other

Abbreviations: BiB, Born in Bradford; BPA, Bisphenol A; DBP, Disinfection by-products; Duisburg, Duisburg birth cohort; EDC, Endocrine disrupting chemicals; EDEN, Study on the pre and early postnatal determinants of child health and development; ELFE, Etude Longitudinale Francaise depuis l'Enfance; ENRIECO, Environmental Health Risk in European Birth Cohorts; EU, European Union; HUMIS, Norwegian Human Milk Study; INMA, INMA-Environment and Childhood Project; KANC, Kaunas cohort; KOALA, KOALA Birth Cohort Study; MoBa, Norwegian Mother and Child Cohort Study; PARIS, Pollution and Asthma Risk: an Infant Study; PBC, Pregnancy–birth cohort; PELAGIE, Longitudinal study on pregnancy abnormalities, infertility, and childhood; RHEA, Mother Child Cohort in Crete; UDWDS, Urban drinking-water distribution system.

* Corresponding author at: Water and Health Laboratory, Cyprus International Institute for Environmental and Public Health in association with Harvard School of Public Health, Cyprus University of Technology, Irenes 95, Limassol 3041, Cyprus. Tel.: +357 25002398; fax: +357 25002676.
E-mail address: konstantinos.makris@cut.ac.cy (K.C. Makris).

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Water and health

disinfection by-products were mostly studied in the PBC around the globe, while fluoride, atrazine, perfluorinated compounds, tetrachloroethylene, and lead were studied to a lesser extent as water contaminants. It appears that chemical-based water contamination and corresponding human exposures represent a largely underappreciated niche of exposure science pertaining to pregnant mother and children's health in PBC. Future PBC studies should grasp this opportunity to substantially reform elements of water contamination in their exposure assessment protocols and effectively combine them with their epidemiological study designs.

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1. Introduction (Setting the scene)

The regulatory context for efficient monitoring of Parma Declaration commitments on Environment and Children Health was adopted at the 5th ministerial conference on Environment and Health to protect children from chemical hazards (WHO, 2012). Similarly, a joint effort by United Nations Economic Commission for Europe and the WHO Regional Office for Europe was backed up by 36 countries signing the protocol on Water and Health, which is primarily aimed at preventing, controlling, and reducing water-related disease (UNECE/WHO Europe, 2006). An instrumental effort recently compiled technical features of EU-based pregnancy–birth cohorts (PBC) (Vrijheid et al., 2012). Out of 37 registered EU PBC, only 13 and 12 cohorts assessed water contamination and noise, respectively (Vrijheid et al., 2012). The limited representation of water contamination in PBC could be partially ascribed to the fact that the developed world has for quite a while rested on the success of post Second World War intervention of chlorination treatment and spread of centralized water treatment facilities, eradicating the water-borne and microbially-originating burden of disease.

Water quality surveillance data collected during the past decade within urban drinking-water distribution systems (UDWDS) call for re-evaluation of water and health issues in the developed world. For example, an increasing number of USA-based water-borne outbreaks have been ascribed to chemicals/toxins (27%), or to *Legionella* spp. (27%) or other bacteria (17%) (Liang et al., 2006). According to a report by the U.S. Government Accountability Office, the number of annual water-borne outbreaks (both of chemical and microbiological origins) may be actually exceeding current estimates, highlighting the alarming number of health-related breaches in drinking-water going unreported (U.S. GAO, 2011). The EU drinking-water directive (98/83/EC) is also under scrutiny by scientific experts and stakeholders on whether extensive revision is necessary (Jørgensen et al., 2008).

Global stressors like (micro) climate and demographics, including population size drastically reform in urban areas (UN-ESA, 2012), calling for the attention of regulatory bodies and local water authorities towards sustainable urban drinking-water management practices. A striking fact is the >50% of urban population living in small urban centers with fewer than half a million inhabitants, while the urban population is >50% of the world population and increasing in magnitude with time (UN-ESA, 2012). Gradually-changing or acute shocks associated with technological threats and deficiencies in potable water quality are encountered or anticipated in the near future, particularly in aging urban UDWDS pressured by increasing water demand by urban dwellers. Evolving socio-economic disparities among neighborhoods within the same city and health inequalities (Pickett and Pearl, 2001), are expected to also modify the magnitude and variability of water-borne contaminant exposures and their health effects.

This commentary will attempt to highlight the bottlenecks and opportunities associated with emerging water and health issues in urban settings, aiming at stimulating fruitful discussions among relevant stakeholders. The focus of this commentary was to challenge the notion of water quality conservation in urban areas enjoying centralized drinking-water treatment. The size of urban community served by a single UDWDS has increased given the last couple of decades urbanization trends, necessitating shifts in performance and reliability of water provision by water authorities. Concomitant challenges to maintain finished water quality are warranted to be tackled in the context of increased urban agglomeration trends, and thus, increased potable water demand at distant neighborhoods within the same city. The limited inclusion of drinking-water contaminants into exposure assessment protocols of the current PBC will offer them the opportunity to consider strengthening their water-based exposure assessment schemes. This work was intended to offer a broader perspective of the issues mentioned above, rather than applying the strict principles of a systematic review or meta-analysis.

2. Methods

2.1. Representation of water contaminants in pregnancy and birth cohorts

Peer-reviewed publications from pregnancy–birth cohorts were identified from a comprehensive search in three scientific databases queried *via* PubMed (1950 onwards), Scopus (1960 onwards), and Web of Science (1970 onwards). Search in Scopus using a keyword combination "Pregnan* OR Birth* AND Cohort*" yielded the highest number of publications originating from PBC, worldwide. The top four regions were selected, based on the number of relevant publication hits during this first stage screening; the search for PBC in the European Union (EU) resulted in 21,158 peer-reviewed publications, followed by United States (14,558), Canada (2338) and Australia (2348). Further screening for the keyword "water" in the full text resulted in 914, 671, 110 and 106 from the aforementioned regions, respectively. Studies resulted from this step were further screened for articles by applying filters with a mention for the following in their full text (i) either for a human health outcome or (ii) water consumption/intake characteristics, analyses of chemicals/contaminants in drinking-water and/or biomarker measurement in biological samples. Resulting effort narrowed the hits to 420, 345, 38, and 35, respectively. Eligible studies were assessed for inclusion by reading either the full text or abstract or both. This non-exhaustive literature search eventually resulted in 17, 14, 1, and 5 publications addressing water contaminants and specific health outcome observed pre- or postnatally in the PBC from EU, US, Canada and Australia, respectively (Fig. 1A).

Additionally, a closer attention was paid on the PBC (both completed and in progress) located in the EU-27 group of countries given their larger number of related publications (Fig. 1A). This was facilitated by the publicly-available comprehensive electronic databases *viz*., (i) Inventory of ENRIECO (Environmental Health Risk in European Birth Cohorts) (http://www.enrieco.dk/Default.asp), and (ii) BIRTHCOHORTS.NET (http://www.birthcohortsenrieco.net), and (iii) CHICOS (http://www.chicosproject.eu/cohorts). In concurrence with Scopus findings, searching electronic databases resulted in a total of 76 eligible PBC in the EU (of which 46 met ENRIECO's criteria), and, finally, a total of 12 PBC was gathered and retained that addressed water contaminants and health monitoring (the same as those mentioned by Vrijheid et al., 2012). Two INMA cohorts, old and new (Vrijheid et al., 2012), were considered as a single PBC in this work. The following PBC (alphabetically) were selected (full names in Table 1) with their number of peer-reviewed publications in parenthesis: BiB (9), Duisburg (15), EDEN (38), ELFE (8), HUMIS (3), INMA (54), KANC (12), KOALA (41), MoBa (43), PARIS (51), PELAGIE (10), and RHEA (26). SELMA (a Sweden-based birth cohort) (Bornehag et al., 2012) was excluded, because it did

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