**Article:**

Setty, K, Bartram, J orcid.org/0000-0002-6542-6315, De Roos, AJ et al. (1 more author) (2020) Water safety plans and risk assessment: A novel procedure applied to treated water turbidity and gastrointestinal diseases. International Journal of Hygiene and Environmental Health, 229. 113435. ISSN 1438-4639

https://doi.org/10.1016/j.ijheh.2019.113435

**November 15, 2019**

**Letter to *International Journal of Hygiene and Environmental Health***

Dear Madam/Sir:

We are writing, having read the in-press article "Water safety plans and risk assessment: A novel procedure applied to treated water turbidity and gastrointestinal diseases" by Muoio et al. published online 13 September 2019. The article is framed around the increasingly important issue of Water Safety Plans (WSPs) (Bartam et al., 2009; WHO, 2004) and their health impacts (Gelting et al., 2012; Gunnarsdottir et al., 2012; Setty et al., 2017). It cites our own analyses of relationships between site-specific drinking water–related exposures and health impacts (Beaudeau, 2018; De Roos et al., 2017; Setty et al., 2018). Muoio et al. (2019) suggest epidemiological analyses are overly complex and that risk management for drinking water treatment systems can more easily be optimized to improve health through engineered turbidity reduction. We have three independent concerns about the paper.

First, while framed around WSPs, the study does not respect their basic principles. Water Safety Plan guidance and case studies consistently emphasize the importance of team approach, catchment-to-consumer risk analysis, and iteration. The study description is limited to one "novel" component of the water supplier's risk assessment efforts, which recommends conventional water treatment using a long-accepted criterion (turbidity reduction) to address health risks associated with drinking water contamination. Muoio et al. (2019) justify their approach by stating "Setty et al. (2018) propose using the incidence rate of gastrointestinal diseases (cases/person-day) as a definition of risk in the context of WSPs." To correct this statement, we did not intend this meaning, nor define "risk" or propose gastroenteritis as the only outcome of importance for all WSPs. Core definitions of these concepts should default to the WSP manual (Bartram et al., 2009), where risk associated with a wide range of hazards is described by likelihood and severity. Since risk characterization is tailored by location, the highest priorities for any given Water Safety Plan are likely to vary (e.g., Setty et al., 2017).

Second, Muoio et al. assume and encourage adoption of a fixed relationship between turbidity exposure and disease risk, which is known to vary widely and depend on context. Based on a sizeable body of evidence, our research (Beaudeau, 2018; De Roos et al., 2017; Setty et al., 2018) indicates that the association between turbidity and disease risk is context specific. The nature of the turbidity indicator (cloudiness of a water sample) may or may not relate to disease in a given context – logically, a water source displaying raised turbidity due to suspended silt or algal growth might present a similar turbidity value but radically different health risk than a sewage-contaminated sample containing viable human pathogens. Several reviewed studies have found seasonal or local conditions such as river flow rate and water temperature to modify the relationship between turbidity and gastroenteritis (Beaudeau, 2018; De Roos et al., 2017). Additionally, several studies have reported evidence of a non-linear relationship, suggesting exposure-response significance only at the highest levels of measured turbidity. For these reasons, we have recommended time-series research of water supplies considering various local conditions (climatic, source water, and treatment approaches), to identify specific contexts in which turbidity may be a useful proxy for microbiological contamination and disease risk.

The proposed procedure in Muoio et al. (2019) "to determine the relationship between drinking water turbidity and gastroenteritis incidence" derived from five excess relative risk data points selected from the literature, rather than estimating the relationship directly. They represent surface water supplies and populations in vastly different geographies, making it difficult to draw strong conclusions about their relevance to Tuscany, Italy. The selected data points exclude the possibility of no relationship, even though several published studies have found no association between turbidity or particle count in finished water and gastroenteritis outcomes; for instance, only 11 of the 17 studies in Beaudeau's 2018 systematic review showed a significant and plausible association. Thus, the selection of a subset of data in Muoio et al. (2019) based on "WTPs and boundary conditions similar to our case studies" appears to be biased towards a significant positive association. Further, their justification for using the median value improperly implicates outlying values as "out of range" rather than a reflection of true variability. Beaudeau (2018) specifically discouraged such meta-analyses and health impact assessments, which require attention to the choice of locally adapted risk functions. Lacking local calibration of the health risk relationship, the Muoio et al. (2019) approach simply targets reducing turbidity to the greatest extent possible, which ignores cost and other tradeoffs.

Third, health risk may be concentrated in short periods of exposure arising from transient risks and process underperformance (Hunter, 2007). Optimization of a water supply system should therefore account for failure modes as well as steady-state performance. Muoio et al. (2019) deal with the latter but omit the former, despite evidence of episodic outbreaks in treated water supplies around the world (Hrudey and Hrudey, 2007). In Muoio et al. (2019), the turbidity time series data did not appear to have a single steady baseline, which draws into question the assumption of steady-state treatment operation and usefulness of these data alone to assess health impact. Controlling for background patterns due to other influences during the study period may be warranted, especially at Plant C. The calculation method in Muoio et al. (2019) relies on a daily turbidity measurement, daily turbidity average, or weekly turbidity measurement over a three-year period. This data resolution may not capture intra-day or intra-week variability. Using the full range of values (including daily turbidity maxima) rather than a central tendency might offer more value to characterize intermittent risks.

While we welcome efforts to enhance the scientific basis for water safety planning and health improvement, we are concerned that the publication "Water safety plans and risk assessment: A novel procedure applied to treated water turbidity and gastrointestinal diseases" could lead researchers and practitioners into a false sense of complacency. While WSPs represent a standardized framework, the site-specificity of the resulting plans underpins their utility (Bartam et al., 2009). Setty et al. (2018) indeed recommended simplified tools for widespread use in WSP development and revision, since epidemiological studies are resource-intensive; however, such tools would need to provide new information to fairly reflect risk likelihood and severity, leading to potentially effective mitigation options. Theoretical performance analysis, such as in Muoio et al. (2019), may prove useful for comparing potential treatment interventions (e.g., in plant design or upgrade decisions) but represents a limited and insufficient approach to managing public health and other water supply risks.

Karen Setty, PhD, ORISE Postdoctoral Fellow, U.S. Environmental Protection Agency[1]
Jamie Bartram, PhD, Director Emeritus, The Water Institute at University of North Carolina at Chapel Hill and Professor, University of Leeds
Anneclaire J. De Roos, PhD, Associate Professor, Drexel University Dornsife School of Public Health
Pascal Beaudeau, PhD, Epidemiologist, Santé Publique France

*[1]The views presented are those of the authors and do not represent EPA policy.*

**References**

Bartam, J., Corrales, L., Davison, A., Deere, D., Drury, D., Gordon, B., Howard, G., Rinehold, A., Stevens, M., 2009. Water Safety Plan Manual: Step-by-step risk management for drinking-water suppliers. World Health Organization, Geneva.

Beaudeau, P., 2018. A Systematic Review of the Time Series Studies Addressing the Endemic Risk of Acute Gastroenteritis According to Drinking Water Operation Conditions in Urban Areas of Developed Countries. Int J Environ Res Public Health 15.

De Roos, A.J., Gurian, P.L., Robinson, L.F., Rai, A., Zakeri, I., Kondo, M.C., 2017. Review of Epidemiological Studies of Drinking-Water Turbidity in Relation to Acute Gastrointestinal Illness. Environ Health Perspect 125, 086003.

Gelting, R.J., Delea, K., Medlin, E., 2012. A conceptual framework to evaluate the outcomes and impacts of water safety plans. Journal of Water Sanitation and Hygiene for Development 2, 103-111.

Gunnarsdottir, M.J., Gardarsson, S.M., Elliott, M., Sigmundsdottir, G., Bartram, J., 2012. Benefits of Water Safety Plans: Microbiology, Compliance, and Public Health. Environmental Science & Technology 46, 7782-7789.

Hrudey, S.E., Hrudey, E.J., 2007. Published case studies of waterborne disease outbreaks--evidence of a recurrent threat. Water Environ Res 79, 233-245.

Hunter, P., Payment, P., Ashbolt, N., Bartram, J., 2007. Assessment of risk, in: Dufour, A.S., M.; Koster, W.; Bartram, J.; Ronchi, E.; Fewtrell, L. (Ed.), Assessing Microbial Safety of Drinking Water: Improving Approaches and Methods. OECD and World Health Organization, London, pp. 79–109.

Muoio, R., Caretti, C., Rossi, L., Santianni, D., Lubello, C., 2019. Water safety plans and risk assessment: A novel procedure applied to treated water turbidity and gastrointestinal diseases. Int J Hyg Environ Health.

Setty, K.E., Enault, J., Loret, J.F., Puigdomenech Serra, C., Martin-Alonso, J., Bartram, J., 2018. Time series study of weather, water quality, and acute gastroenteritis at Water Safety Plan implementation sites in France and Spain. Int J Hyg Environ Health 221, 714-726.

Setty, K.E., Kayser, G.L., Bowling, M., Enault, J., Loret, J.F., Serra, C.P., Alonsof, J.M., Mateu, A.P., Bartrama, J., 2017. Water quality, compliance, and health outcomes among utilities implementing Water Safety Plans in France and Spain. Int J Hyg Envir Heal 220, 513-530.

WHO, 2004. Guidelines for Drinking-water Quality, 4th ed. World Health Organization, Geneva.