Understanding the Health Impacts of Fecal-Oral Pathogens in Waters Using Quantitative Microbial Risk Assessment (QMRA)

Background. Diarrheal diseases are the third leading cause of morbidity and mortality in children younger than 5 years of age in Africa.[i] Bacteria, viruses and parasites leading to this disease burden are often transmitted through the fecal-oral transmission route involving the contamination of water. Hence, the impact of waterborne pathogens on human health is well established. However, lack of monitoring of enteric pathogens in sewage systems and sewage-polluted water coupled with quantitative evaluations of health risks to guide decision making remains unknown for all geographical regions. This project will therefore generate and leverage important data sets and a promising approach for predicting the prevalence and occurrence of pathogens including antimicrobial resistant pathogens and associated health risks, in African waters at the community level. Further, the incorporation of quantitative risk assessment approaches will allow the results to be used to identify risk management strategies. This work will fill critical data gaps on a global scale as antibiotic resistant pathogens and resistant genes are considered emerging contaminants worldwide.

Research Opportunity. Our research on understanding water quality impacts on human health through risk assessment will contribute directly to this project. The PI has established contacts with researchers at the University of Nigeria, Nsukka – Nigeria and University of Pretoria - South Africa, who have local data sets and ongoing microbial sampling projects for waterborne pathogens in surface waters used for drinking and irrigation. The study will utilize data collected through culture based methods and molecular tools to detect, quantify and document the source of water pollution in local water sources. Pathogens of interests will include, *E. Coli*., *Vibrio cholerae*, Rotavirus, Adenovirus and Norovirus. Collected microbial water quality data will be used for risk assessment to estimate health impacts associated with contamination sources through multiple relevant exposure pathways including recreation, irrigation and drinking water. Additional sampling may be conducted to fill data gaps as well. We have experience in using advanced monitoring tools and building mathematical fate and transport models for environmental contaminants. In order to support QMRA, the persistence of pathogens in these water systems must be adequately represented through mathematical models so that concentrations can be predicted at the point and time of contact. The PIs lab has evaluated hundreds of such data sets in multiple water matrices as part of the Global Water Pathogens Project (waterpathogens.org), but the full impact of utilizing pathogen specific persistence models has yet to be brought to bear on improving QMRAs. To benchmark models with reported incidences of GI illness as well as household water sources, use and water safety practices, our colleague in Nigeria has collected Multiple Indicator Cluster Surveys. Exploratory data analysis, statistical correlation, cluster and principle component analyses will be utilized to elucidate the relationships between source water, treatment plant characteristics, water usage behaviors and health risks. Based on the results of these approaches, regression models or Bayesian networks will be developed to model and predict water quality and health risks in order to provide decision support for infrastructure improvements. In addition to the evaluation described above, the routes of transmission of antibiotic resistance are of utmost importance. The post-doc will also be engaged in modeling data from environmental sources to benchmark with clinical isolates from Nigeria. These analyses will support decision making about stewardship.

AAP Priority Area: Water, Energy and Environment' but has overarching impacts on 'Health and Nutrition' and 'Agri-Food Systems', which require sustainable supplies of clean water.

Publications, Presentations and Grant Writing: The post-doctoral associate will co-author at least two manuscripts for peer review and submit abstracts to present the work at two conferences including the Society for Risk Analysis, which has a newly established regional chapter in Africa. The PI is currently Chair of the Microbial Risk Analysis Specialty Group and serves on the conference program committee. This will provide a valuable networking experience for the scholar as well. The scholar will also be involved in grant writing to support new projects, collaborations and capacity building through Gates Foundation, USAID and NSF.

Leadership and Training: Training is expected to be interdisciplinary given the nature of QMRA. The post-doctoral scholar will be trained in computational methods as well as methods for microbial sampling and analysis to support her ability to collaborate across disciplines and have a complete understanding of the data being utilized. Dr. Joan Rose, the Homer Nowlin Chair in Water Research and 2016 recipient of the Stockholm Water Prize has agreed to co-mentor the post-doctoral associate to facilitate this cross-disciplinary training. Dr. Mitchell and Dr. Rose have a well-established collaborative relationship. In addition to academic mentorship, the mentee will participate in at least 2 research and leadership workshops offered by the Graduate School at MSU and in conjunction with the MSU Postdoctoral Association. The mentee will create an Individual Development Plan and meet regularly with the PI and her lab to ensure a well-rounded experience and opportunities for peer mentorship as well.

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[i] Reiner RC, et al. **Variation in childhood diarrheal morbidity and mortality in Africa, 2000–2015.** *New England Journal of Medicine*. 2018 Sept 19