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Swimmer illness associated with marine water exposure and water quality indicators impact of widely used assumptions

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ABSTRACT

Water quality standards for fecal contamination in recreational waters focus on the measurement of fecal indicator bacteria, such as *Enterococcus*, which covary with pathogens in sources of human waste but are easier, cheaper, and faster to measure than the pathogens themselves.[1,2] Studies that estimate the relationship between fecal indicator bacteria levels and subsequent illness among swimmers often rely on prospective cohort designs. Investigators have used similar designs at a variety of beaches (freshwater and marine), with various sources of pollution (well-defined "point sources," such as sewage treatment discharges, vs. "nonpoint sources," such as urban or agricultural runoff), and using indicator bacteria detected by culture (eg, *Enterococcus* Method 1600) or more rapid molecular methods (eg, *Enterococcus* qPCR).[3–10] Cohort studies require investigators to make many decisions about how to define swimming-related exposure and health outcomes. Studies typically use a small set of exposure definitions and report a limited set of results. For example, investigators often assign daily average indicator bacteria levels to all swimmers at the beach on a given day.[3–7] Cohort studies also follow participants for incident illness over a period of at least 10 days. This follow-up period is long enough to identify a large number of cases and capture relevant pathogen incubation periods but short enough to avoid excessive problems with errors due to poor recall. Despite the importance of definition choices, only three previous studies have reported any alternative estimates, and then only in supporting materials. [6,8,10] To our knowledge, no study of infections to swimmers has systematically studied the effect of definition choices on the stability of risk estimates. Our objectives are (1) to measure the risk of illness that results from swimming at a marine beach affected by dry weather runoff and nonpoint source contaminants; (2) to determine the association between fecal indicator bacteria, measured with culture and molecular methods, and subsequent illness among swimmers; and (3) to investigate the impact of outcome and exposure measurement choices on the results. We consider daily illness patterns among nonswimmers and swimmers after visiting the beach to determine the most sensitive risk periods. We also present a simple stability analysis[11] to assess whether parameter estimates calculated with the de facto standard methodology are sufficiently robust to the choices that govern the presentation of primary results.