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Epidemiologic evaluation of multiple alternate microbial water quality monitoring indicators at three California beaches

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ABSTRACT

Introduction: Advances in molecular methods provide new opportunities for directly measuring pathogens or host-associated markers of fecal pollution instead of relying on fecal indicator bacteria (FIB) alone for beach water quality monitoring. Adoption of new indicators depends on identifying relationships between either the presence or concentration of the indicators and illness among swimmers. Here we present results from three epidemiologic studies in which a broad range of bacterial and viral indicators of fecal contamination were measured simultaneously by either culture or molecular methods along with *Enterococcus* to assess whether they provide better health risk prediction than current microbial indicators of recreational water quality. *Methods:* We conducted prospective cohort studies at three California beaches – Avalon Bay (Avalon), Doheny State Beach (Doheny), Surfrider State Beach (Malibu) – during the summers of 2007, 2008 and 2009. The studies enrolled 10,785 swimmers across the beaches and recorded each swimmer's water exposure. Water and sand samples were collected several times per day at multiple locations at each beach and analyzed for up to 41 target indicators using 67 different methodologies. Interviewers contacted participants by phone 10 – 14 days later and recorded symptoms of gastrointestinal illness occurring after their beach visit. Regression models were used to evaluate the association between water quality indicators and gastrointestinal illness among swimmers at each beach. *Results:* F+ coliphage (measured using EPA Method 1602) exhibited a stronger association with GI illness than did EPA Method 1600 at the two beaches where it was measured, while a molecular method, F+ RNA Coliphage Genotype II, was the only indicator significantly associated with GI illness at Malibu. MRSA, a known pathogen, had the strongest association with GI illness of any microbe measured at Avalon. There were two methods targeting human-associated fecal anaerobic bacteria that were more strongly associated with GI illness than EPA Method 1600, but only at Avalon. No indicator combinations consistently had a higher odds ratio than EPA Method 1600, but one composite indicator, based on the number of pathogens detected at a beach, was significantly associated with gastrointestinal illness at both Avalon and Doheny when freshwater flow was high. *Discussion:* While EPA Method 1600 performed adequately at two beaches based on its consistency of association with gastrointestinal illness and the precision of its estimated associations, F+ coliphage measured by EPA Method 1602 had a stronger association with GI illness under high risk conditions at the two beaches where it was measured. One indicator, F+ Coliphage Genotype II was the only indicator significantly associated with GI illness at Malibu. Several indicators, particularly those targeting human associated bacteria, exhibited relationships with GI illness that were equal to or greater than that of EPA Method 1600 at Avalon, which has a focused human fecal source. Our results suggest that site-specific conditions at each beach determine which indicator or indicators best predict GI illness.

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