Using a large spatiotemporal groundwater quality dataset to delineate a suite of Quantitative Microbial Risk Assessments for private drinking water wells in Ontario

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Approximately 1.5 million individuals in Ontario are supplied by private wells. Unlike municipalities, private well water quality remains unregulated; therefore, owners are responsible for testing, treating, and maintaining their own systems. It is estimated that contamination of private wells is responsible for approximately 80,000 cases of acute gastrointestinal illness per year in Canada, highlighting their significant impact of this water source on human health. Methods: Well water sample submission data from 2010-2017 were analyzed for *Escherichia coli* (*E. coli*) to study the relationship between sampling frequency and *E. coli* detection rates in Ontarian private wells. Detection rates were further analyzed relative to geological (consolidated and unconsolidated aquifers) setting to determine how hydrogeology impacts E. coli detection (via transport) and season. Bivariate statistical analyses were performed when comparing greater than two groups of detection rates (consolidated and unconsolidated depths and seasons) and to quantify associations between groups. Results: Province wide, 702,861 samples from 239,244 wells were analyzed, with detection rates found to increase in concurrence with sample number per well. Statistically significant differences were found between detection rates in consolidated and unconsolidated aquifers ($p = 0.0191$), highlighting geological differences and their potential impact on well water contamination. E. coli detection rates differed significantly with respect to sampling season; rates were markedly higher during summer and fall months compared to spring and winter throughout the province, irrespective of geological setting. Conclusions: Future risk assessments of private well water on human health should consider i) employing repeat sampling methods over an extended period of time as opposed to one-off sampling analysis in order to gain a more accurate representation of well water contamination and to properly evaluate changes in water quality, and ii) creating multiple risk assessment based on the social and physical factors that influence local private well water contamination. Ultimately, this will facilitate a more comprehensive understanding of the pathways and factors of contamination and minimize potential health burdens attributed to contaminated private drinking water systems.