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Top-down and bottom-up management of private groundwater contamination risk: A comparative scoping review of similarities, drivers and challenges in two developed regions

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While developed nations are assumed to provide high groundwater quality security, populations reliant on (typically rural, unregulated) private domestic groundwater wells are often uniquely vulnerable to supply contamination. The potential health ramifications of exposure to contaminated groundwater may be especially grave for immunosuppressed populations residing in service-deprived and climate-vulnerable areas, necessitating concerted government (educational) and household-level (behavioural) action. In response, a growing number of studies (spanning quantitative contamination risk assessments, policy strategies, communicative interventions and householder surveys) have emerged within the last several decades. To date, few investigations have sought to synthesise this literature and ascertain the potential generality of drivers of both private groundwater contamination and preventive responses in high-income countries.

The developed regions of the Republic of Ireland (ROI) and Ontario represent an appropriate point of comparison to establish research transferability. Both regions are characterised by high private groundwater reliance (> 10% of their respective populations), pervasive microbial groundwater contamination and significant associations between acute gastrointestinal illness (AGI) and private well use. Consumption of private well water contributes to approximately 4,800 annual cases of AGI in Ontario and as many as 80% of annual cases of *verotoxigenic E.coli* (VTEC) in the ROI. However, despite similarities, regional discrepancies exist with respect to policy landscapes (e.g., monetary requirements for private water quality testing) and contamination risk profiles (e.g., frequency of extreme weather event concurrence). In efforts to elucidate the potential implications of these phenomena, a scoping review of literature (1990-2022) in the ROI and Ontario outlining risk management measures to prevent private groundwater contamination in the was undertaken. The *SPICE* (Setting, Population/Phenomenon, Intervention, Setting, Perspective) methodology was utilised to inform literature search terms, with Scopus and Web of Science selected as primary databases for article searches. Following removal of duplicate studies and article screening, 92 articles (Canada = 70, ROI = 22) were retained for analysis.

Articles were predominantly comprised of quantitative contamination risk assessment studies (n = 68), with qualitative and quantitative questionnaire investigations (n = 16), interventions (n = 2) and policy studies (n = 6) noticeably less frequent. Quantitative risk assessments published after the year 2000 demonstrated an overwhelming focus on microbial supply contamination, identifying well type and proximity of agricultural activity as significant determinants of supply contamination. Survey studies in both regions also consistently highlighted gender, perceived confidence in maintaining supply and economic and convenience barriers as significant determinants of well user knowledge and behaviour. However, well users in Ontario demonstrated markedly higher rates of prior well testing (irrespective of adherence to regional guidelines), suggesting that incentivised (or free) well testing may lead to significant increases in uptake of well water quality testing. The paucity of identified intervention studies suggests that increased research investigating methods of well user outreach and groundwater risk communication will be necessary in the future to determine the broad efficacy of risk communication in developed nations.