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# Private Groundwater Supply Management as a Response to Flooding Events: Perceptions of Irish Well Owners

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**Abstract.** Over 720,000 people in the Republic of Ireland rely on private groundwater resources (i.e. private wells) for daily consumption, and as these extractions are unregulated, users are solely responsible for managing/mitigating contamination risks to their supplies. However, low levels of exposure to appropriate guidance on well water protection and ongoing maintenance are not uncommon, particularly regarding responses to sporadic environmental threats, such as significant flooding. Despite this, very little is known regarding the factors leading to (or inhibiting) preparedness among groundwater-reliant individuals in the context of health threats triggered by flooding events. Accordingly, the purpose of this study is to bridge this knowledge gap and explore current behaviours, knowledge, risk perception and experience relating to this issue in the Irish context. This was attempted via a combination of quantitative and qualitative methodologies, including a nation-wide online survey with 405 Irish well owners and six localized focus group meetings. Results show the need to go beyond knowledge-based interventions, and use socio-hydrogeological and/or socio-epidemiological approaches to target risk perception and potential structural constraints as a mean to turn protective intentions into protective actions when dealing with adverse effects of sporadic natural events; particularly in a changing climate.

**Keywords:** Private wells, Flooding, Survey, Focus Group, Preparedness, Health behaviour

## 1 Introduction

Flooding events have been shown to increase the risk of human exposure and subsequent outbreaks of waterborne infection, particularly in communities that rely on groundwater supplies for daily consumption (Andrade et al., 2018). Compounding this,

both the frequency and intensity of flooding events are predicted to increase over the coming years as a result of anthropogenic climate change (Arnell & Gosling, 2016). As such, incentives to protect groundwaters against flood contamination are paramount in communities that rely on groundwater supplies for daily consumption. However, a barrier often faced by intervention strategies is motivating people to undertake desired behaviours.

Individual responses (protective or otherwise) to potentially hazardous circumstances are complex and can be influenced by myriad factors, such as risk perception (Bradford et al., 2012) and previous experiences. With regard to well stewardship, structural constraints and personal motivations, or lack thereof, also represent significant barriers to protective action, at times even more so than knowledge gaps (Kreutzwiser et al., 2011; Chappells et al., 2015). Additionally, low levels of exposure to appropriate guidance on well water protection and ongoing maintenance are not uncommon. This, coupled with widespread lack of well stewardship (i.e. water treatment, continuous maintenance, and well water testing) among private well owners even under normal circumstances (Kreutzwiser et al., 2011; Hynds et al., 2013), could make well users ill equipped to prevent and manage the consequences of flood-triggered contamination. However, to date no studies have identified the factors leading to (or inhibiting) preparedness among groundwater-reliant individuals in the context of the health threats triggered by flooding events. Thus, the purpose of this study is to bridge this knowledge gap and explore current experience, risk perception and behaviours relating to this issue among Irish groundwater supply users.

## 2 Methods

The current study was undertaken in the Republic of Ireland (RoI) where over 720,000 residents (> 15% of national population) are supplied by unregulated groundwater sources, which are exempted from compliance with the European Commission (Drinking Water) Directive 98/83/EC (EU 2018). Both quantitative and qualitative approaches were employed in order to gage groundwater users' perspectives on the issue at hand.

Quantitative data were collected via an online survey conducted between November 2017 and February 2018 and disseminated among well users in the RoI through local organizations, local authorities, governmental bodies and social media platforms. The implemented questionnaire comprised 39 questions, and included multiple-choice, checkbox, numerical, forced preference ranking, and Likert-scale style questions. Questions included in the survey belonged to four distinct sections, namely i) respondent and household-related information, ii) groundwater supply characteristics, iii) previous experience with well water testing, and iv) flood-related risk perception, experience, knowledge and behaviours.

Additionally, focus group meetings were hosted in specific locations in RoI as a qualitative methodology for gathering data. These were conducted from April to July, 2018, with five sessions meeting the minimum number (≥4) of participants typically required to be considered successful (Krueger 1997). One further focus group was successfully completed despite lower participant numbers, and no data were collected for the remaining three sessions due to insufficient participant numbers. Participants had

to be ≥18 years of age and characterised as being a private well user/owner. Recruitment was undertaken via invitation letters to between sixty and one hundred households in chosen groundwater-reliant areas or via local institutions (e.g., local parish, school or community centre). Focus groups were steered by a topic guide based upon the Health Belief Model (HBM) framework (Rosenstock, 1974). Primary topics covered included: i) general thoughts on water quality locally and nationally; ii) general thoughts on their own water; iii) previous flood experience, perceived vulnerability and perceived severity; iv) general thoughts and attitudes regarding protective behaviours; v) thoughts on social acceptance and one's own ability to take protective action; and iv) trusted/preferred information sources. Focus group participants also completed a short survey comprised of twelve multiple-choice questions. Questions examined ages of participants and all household members, gender, residential ownership, number of years living in current household, and household location. Participants were also asked to state whether they drank from their private household well and if they used any microbial treatment before consumption (e.g., chlorination, UV treatment, or reverse osmosis), and if they had (or new others who had) experienced flooding events near (≤100 meters) their groundwater supplies.

In order to determine respondents' main characteristics, knowledge gaps, risk perception, awareness levels, and engagement or intended engagement with desired behaviours, descriptive statistics were used to analyse the quantitative data. With regards to the analyses of focus group data, all meeting recording were transcribed, and manually analysed/coded in order to identify obvious patterns, which were interpreted in the context of the HBM.

# 3 Results

## 3.1 Online Survey

All 26 counties in RoI were represented by a total of 405 survey respondents. The majority were male (58.5%) and of all respondents, 40.5% were in the 35 to 49 age range (13.8% below and 42.7% above). Overall, 94.8% of respondents lived in a rural area, with 5.2% from villages, towns or another (peri)urban settlement. Young children (<5 years) and persons over 65 years of age resided in 20% and 39.5% of the surveyed households, respectively. In all, 81.7% of study participants were supplied by a private groundwater source (i.e. household well), with the remainder self-reporting as members of private group water schemes. Of the latter participants, 59.5% reported use of a microbial water treatment system prior to consumption (i.e. chlorination, UV lights, etc.), compared to just 14.2% of respondents that owned a household well.

One in five survey respondents (19.8%) reported previous experience with flooding near their groundwater supplies (direct experience), 18.8% reported no direct flood experience but knew others that have experienced flooding in the past (indirect experience), 55.0% declared no experience with flooding, and 6.4% abstained from answering the question.

With regards to risk perception, 69.1% of all participants believed it to be unlikely or very unlikely that future flooding could negatively impact their supplies (low objective risk perception) and 57.5% of participants reported not being at all worried that

their wells could become contaminated by future floods (low affective risk perception). Even among respondents that have directly experienced floods in the past, low levels of objective and affective risk perception were exhibited, equating to 41.3% and 26.3% of them, respectively. Overall, just 0.7% of respondents suspected that an illness to a member of their household was caused by their well being contaminated. Moreover, Figure 1 shows actual versus conjectural responses to flooding by respondents with and without flood experience.

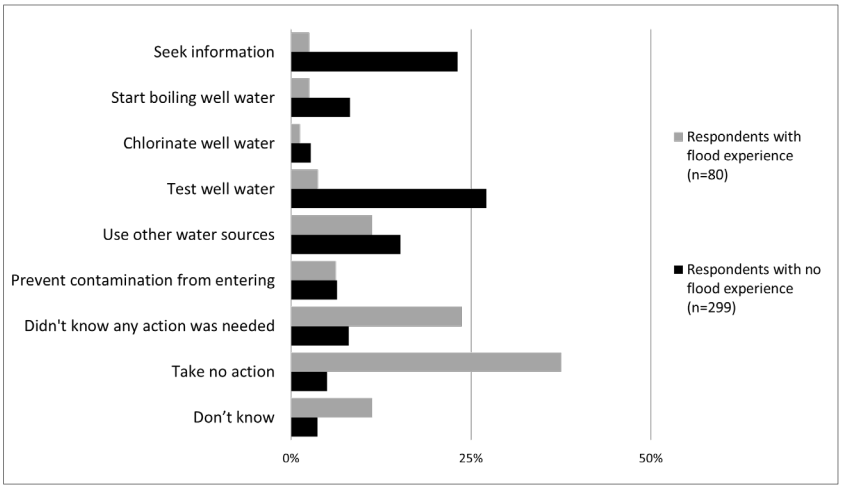


**Figure 1:** Composition of actual response to flooding by survey respondents that have directly experienced it (n=80) versus indented responses by respondents that have not experienced floods near their supplies in the past (n = 299).

### 3.2 Focus Groups

In total, 35 private household well owners participated across the six successfully conducted focus groups (FG1, FG2, FG3, FG5, FG7, FG8; Table 1). Participation was balanced between genders with a total male to female ratio of 1.19 (i.e. 19 male and 16 female participants). Most participants reported drinking the well water (91.43%), but few (14.28%) made use of a microbial water treatment (i.e. UV, reverse osmosis or chlorination) before consumption. Of all participants, 22.71% have experienced flooding events near their own well in the past (direct experience) and a further 25.71% knew others that have experienced this issue (indirect experience).

In general, participants voiced satisfaction with their own well water, mentioning good taste, lack of issues and praise from visitors, despite very infrequent well water testing habits. The vast majority of participants did not consider themselves at risk of flooding. The most commonly cited reason was that their well was elevated, while participants that experienced small-scale floods tended to associate flooding and flood-related contamination to large-scale events only. Nevertheless, most participants agreed that their wells would be at risk of contamination if flooding did occur, particularly if the well got inundated. In the case of floods nearby (<100 meters) some participants

reported that they would not be concerned about contamination. When asked about the reasons for concern the vast majority raised the issue of nearby agriculture, including chemical and animal contamination, only acknowledging human sources (e.g. septic tanks) when probed.

**Table 1:** Focus groups description, including code, date, recruitment strategy, number of participants and the level of flood experience in the area

| Focus Group | Date (2018) | Recruitment strategy | Nº of Participants | Level of flood experience in the area (in the past 10 years) |
|---|---|---|---|---|
| FG1 | 28/04 | Letters | 9 | No history of floods in the area |
| FG2 | 28/04 | Letters | 2 | No history of floods in the area |
| FG3 | 05/05 | Letters | 6 | Large-scale nearby floods in the past 5 years |
| FG4 | 05/05 | Letters | 1 | Large-scale nearby floods in the past 5 years |
| FG5 | 07/06 | Local recruiter | 6 | Incidences of small-scale localised flooding |
| FG6 | 07/06 | Local recruiter | 0 | Incidences of small-scale localised flooding |
| FG7 | 23/06 | Local recruiter | 4 | No history of floods in the area |
| FG8 | 18/07 | Letters | 8 | Incidences of small-scale localised flooding |

Regarding post-flood action, most participants stated that they would get the well water "checked"/"tested", with some also reporting that they would boil the water before drinking. However, amongst the few that have experienced flooding, only one participant pursued protective action (i.e. installing a treatment system), other participants attributed lack of action to "putting on the long finger". The following statement by one of the participants at the end of a meeting succinctly summarises the primary findings of this study:

*FG5: "The highest risk to all wells is lack of information and lack of knowledge. People not even understanding how, where the water comes from, let alone what to do with it. If people understand the risk of flooding, 90% of them would get a remedy fairly quick, it's just that they're not aware of the risks."*

## 4 Discussion

The research described in this paper addresses the knowledge gap concerning the experiences, risk perception and behaviours of well owners in RoI with regard to the adverse health effects of flooding near their supplies. Results identified low levels of protective behaviour by participants with previous flood experience. It is considered that this is at least partially attributable to low levels of risk perception exhibited by these respondents regarding the effects of nearby flooding to their own well water quality. According to Bradford et al. (2012) risk perception is a primary driver of health behaviours (i.e. behaviours aimed at protecting health), along with well stewardship (Morris et al., 2016).

Findings also indicate a significant disparity between intended and actual engagement with protective actions, i.e. actions performed by respondents that have previously

dealt with the issue versus conjectural actions intended by respondents with no flood experience. Previous work by Sandman & Weinstein (1993) explains that there are practical and psychological barriers when transforming intention into action in the context of well stewardship. However, in the Irish context, these barriers could be further exacerbated by the lack of publicly available evidence-based guidelines on what to do if flooding happens near groundwater supplies, as well as lack of socio-hydrogeological and/or socio-epidemiological methodologies to engage with these at-risk populations.

## 5 Concluding Remarks

Results from this study reinforce the need to go beyond knowledge-based interventions, and employ socio-hydrogeological and/or socio-epidemiological approaches to target risk perception and potential structural constraints as a mean to turn protective intentions into protective actions when dealing with adverse effects of sporadic natural events; particularly in a changing climate.

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