# Behavioral Pathways to Private Well Risk Mitigation: A Structural Equation Modeling Approach

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ORIGINAL ARTICLE

# Behavioral pathways to private well risk mitigation: A structural equation modeling approach

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**Abstract**
Complex, multihazard risks such as private groundwater contamination necessitate multiannual risk reduction actions including seasonal, weather-based hazard evaluations. In the Republic of Ireland (ROI), high rural reliance on unregulated private wells renders behavior promotion a vital instrument toward safeguarding household health from waterborne infection. However, to date, pathways between behavioral predictors remain unknown while latent constructs such as extreme weather event (EWE) risk perception and self-efficacy (perceived behavioral competency) have yet to be sufficiently explored. Accordingly, a nationwide survey of 560 Irish private well owners was conducted, with structural equation modeling (SEM) employed to identify underlying relationships determining key supply management behaviors. The pathway analysis (SEM) approach was used to model three binary outcomes: information seeking, post-EWE action, and well testing behavior. Upon development of optimal models, perceived self-efficacy emerged as a significant direct and/or indirect driver of all three behavior types—demonstrating the greatest indirect effect ($\beta = -0.057$) on adoption of post-EWE actions and greatest direct ($\beta = 0.222$) and total effect ($\beta = 0.245$) on supply testing. Perceived self-efficacy inversely influenced EWE risk perception in all three models but positively influenced supply awareness (where present). Notably, the presence of a vulnerable (infant and/or elderly) household member negatively influenced adoption of post-EWE actions ($\beta = -0.131$, $p = 0.016$). Results suggest that residential and age-related factors constitute key demographic variables influencing risk mitigation and are strongly mediated by cognitive variables—particularly self-efficacy. Study findings may help contextualize predictors of private water supply management, providing a basis for future risk-based water interventions.

**KEYWORDS**
behavior, extreme weather events, groundwater contamination, private wells, risk perception

## 1 | INTRODUCTION

Environmental threats to public health are increasingly defined by multiple hazards and complex spatiotemporal dynamics due to phenomena such as extreme weather events (EWEs) and land-intensive industrial activities. Rigorous behavior adoption will thus likely be required where absence of regulatory risk management tools places the onus of action on lay or disadvantaged populations (Keys et al., 2019; Shreve et al., 2016). The construct of risk perception has long formed the basis of risk response frameworks and emerged as a key behavioral predictor in many individual decision-making contexts (Ferrer & Klein, 2015; Gaube et al., 2019; Goerlandt et al., 2020). However, behavioral science practitioners have progressively advocated for broader, systematic conceptions of risk perception in modeling contemporary risk reduction behaviors, noting that subjective probabilistic and consequential risk appraisals alone may not always (directly or indirectly) influence behavior (Rundmo & Nordfjærn, 2017; Siegrist & Árvai, 2020; Wilson et al., 2019). This assertion pervades much recent water-centered behavioral research, which establishes that the effects of risk perception (as conventionally measured) may be superseded or mediated by factors such as hazard source evaluation, climate change-related concerns, and self-efficacy (behavioral competency) (Babcicky & Seebauer, 2017; Carlton & Jacobson, 2013; Lemée et al., 2019; Ochoo et al., 2017; Willcox-Pidgeon et al., 2017). Water-related risks (spanning flooding, drowning, and drinking water contamination) are among the costliest in financial and human health terms globally and compounded by socioeconomic and geographical inequalities (United Nations Office for Disaster Risk Reduction [UNDRR], 2020; World Health Organization and the United Nations International Children's Emergency Fund [WHO and UNICEF], 2021). Accordingly, a more comprehensive delineation of risk perception and other variables reflecting today's water risk landscapes may be of marked utility in enabling accurate behavioral characterization and identification of intervention control points.

In terms of global ubiquity and complexity, private domestic groundwater contamination represents a significant contemporary water risk. Private groundwater wells are largely located in rural areas (typified by prevalent agroindustrial activity and localized wastewater disposal), with poorly maintained supplies thus highly susceptible to microbial contamination (Lall et al., 2020; Murphy et al., 2017). This human health concern is exacerbated by the rising frequency and unpredictability of EWEs, which may accelerate environmental transport of pathogens into private wells and demand focused hazard evaluation from well owners (Andrade et al., 2018; Arnell & Gosling, 2016). As private wells (comprising individual domestic and community-level supplies) are typically unregulated, the duty of care lies with well owners themselves (Grönwall & Danert, 2020; Villholth & Conti, 2018). Supply management measures include water treatment, periodic inspections of wellhead integrity, and routine and event-based (e.g., post-flood) water quality testing—all of which entail appreciable financial investment and knowledge. As rural well owners must variously overcome issues such as rural isolation, lack of information, climate vulnerability and socioeconomic disadvantage, self-efficacy and climate change concern may constitute potentially important behavioral determinants (Argent, 2019; Cole & Murphy, 2014; Curtis et al., 2017). In spite of the potential health consequences of inaction, current levels of private well maintenance globally are low—indicating that well users do not perceive contamination risk to an actionable extent (Colley et al., 2019; Mooney et al., 2020; Munene & Hall, 2019; Schuitema et al., 2020).

Understanding the role of multiple concurrent behaviors and associated predictors during intervention design is integral to development of successful risk communication campaigns and reduced exposure to health hazards (Atkin & Rice, 2012; Martinez & Lewis, 2016). Factoring in the importance of EWEs toward contaminant mobilization, baseline groundwater quality fluctuations, and the increased requirement for information acquisition, adoption of post-EWE supply maintenance measures merits attention alongside historical well water testing and information seeking behaviors. While behaviors and predictors of such actions are often poorly measured or place-dependent, recent research suggest that aforementioned latent constructs such as climate change concern, risk perception of EWE impacts and self-efficacy may exercise a significant influence (McDowell et al., 2020; Schuitema et al., 2020). As such, an expanded focus on perceptual, cognitive factors may shed light on both direct and indirect pathways toward adoption of well maintenance and enhance the efficacy of future (communicative) groundwater interventions. Although existing literature has sought to better conceptualize various demographic, experiential, and supply-specific factors influencing private well maintenance, the majority of studies have neglected to identify pathways and relationships between behavioral precursors (Hynds et al., 2018; Re, 2015). While relevant approaches such as structural equation modeling (SEM) have been applied in the context of "generic" drinking water management (Ho & Watanabe, 2018; Reese et al., 2019), they have yet to be utilized within the sphere of groundwater management.

The Republic of Ireland (ROI) emerges as a relevant case study in the context of private groundwater risk communication due to its high reliance on unregulated private wells and vulnerability to supply contamination (Naughton & Hynds, 2014). The ubiquity of livestock-based agriculture and domestic wastewater treatment systems (i.e., septic tanks) predisposes a significant proportion of Irish private well users to supply contamination where supplies are inappropriately maintained (Gill et al., 2018). The resultant human health burden is considerable as it is estimated that up to 80% of annual nonoutbreak cases of *Verotoxigenic E. coli* (VTEC) enteritis may be associated with private well exposure (Health Protection Surveillance Centre (HPSC), 2019). With previous research identifying a significant temporal link between EWEs and incidence of acute gastrointestinal illness (AGI) deriving from private supplies nationally, risk communication is of pivotal importance toward educating susceptible Irish households and addressing low levels of supply maintenance (Boudou et al., 2021; O'Dwyer et al., 2016, 2021). While a monetary grant for private well rehabilitation works and supply maintenance information are available via local authorities, a coordinated, empirically driven risk communication intervention aimed exclusively toward well owners has yet to be developed in the ROI (Department of Housing, Local Government and Heritage, 2021). Moreover, much existing information relating to well construction and structural integrity is regarded as piecemeal and overly technical for lay well owners (Hynds et al., 2013). As the requirement for a national-level risk intervention has been recognized, audience and behavioral characterization represents a necessary procedure within the larger context of national groundwater risk management (Hynds et al., 2013; Hynds et al., 2018a; Schuitema et al., 2020).

In response, the current study adopts pathway analysis—a SEM method enabling quantification of pathways between potential predictors and behavioral outcomes, and prioritization of critical behavioral control points. Using data from a 2019 survey of Irish private well users (Mooney, O'Dwyer, Hynds, 2021; Mooney, O'Dwyer, Lavalleee et al., 2021), three behavioral actions (well testing, post-EWE actions, and information seeking behavior) are analyzed alongside a suite of manifest and latent variables to elucidate central relationships and pathways determining adoption of well maintenance actions. Study findings may inform future risk communication interventions seeking to minimize exposure to contaminated water and reduce the risk of exposure to waterborne infection.

# 2 | METHODOLOGY

## 2.1 | Survey design

A cross-sectional survey of Irish private well users was employed to gather behavioral data. The survey followed a structured, standardized format and was adapted from the KAP (knowledge, attitudes, and practice) model (Warwick, 1983). The KAP model seeks to examine interrelationships between attitudes, beliefs, and practices and has been previously used to investigate private well user behaviors (Lavallee et al., 2021). The KAP model was selected to ensure comprehensiveness of question types and comparability with prior research (e.g., Lavallee et al., 2021). The model was neither used for the purpose of specific theory validation nor adhered to strictly, with self-efficacy, risk perception, and concern examined in addition to the three dimensions of KAP. Further details relating to survey development and question categories can be found in Mooney, O'Dwyer, Lavalleee et al. (2021) and Mooney, O'Dwyer, Hynds (2021). The full survey is presented in the Appendix.

The survey consisted of 41 questions and four sections. The first section questioned well users about their sociodemographic background and private groundwater supply characteristics (connection type, construction history, and functional use). Each subsequent section of the survey examined one core well maintenance behavior (i.e., water quality testing, adoption of post-EWE protective actions, and information seeking) and associated cognitive and experiential factors (e.g., supply awareness, EWE experience). The second section focused on supply testing history, maintenance knowledge, and recent household history of gastrointestinal illness. The third section inquired about protective actions undertaken in the immediate aftermath of recent (named) EWEs and respondent experiences, concerns, and risk perceptions relating to EWE impacts on well water quality. The final section elicited respondents' history of seeking out supply maintenance information and self-perceived confidence in undertaking supply maintenance.

## 2.2 | Survey dissemination

The survey was circulated online and in-person over a 3-month period (mid-September to late-November 2019). The electronic survey was hosted on the online survey platform *SurveyMonkey* and disseminated via email, while the physical (print) survey was distributed within Irish rural vocational colleges. Physical surveys were undertaken in a group setting with a moderator present and collected upon completion.

As there is currently no national data repository of private domestic wells, a purposive sample of relevant organizations was used to disseminate surveys to private well users. The online survey was distributed through a series of relevant rural interest groups, government bodies and educational institutions after advance disclosure of study aims and parameters. To ensure privacy, respondent ID and IP addresses were not collated. Mean online survey completion time was 13 min, with no incentive (financial or otherwise) offered to participants. The physical survey was disseminated within four consenting agricultural/horticultural colleges in counties Galway, Kilkenny, Limerick, and Tipperary. Agricultural colleges were selected for physical survey dissemination as it was postulated that surveying undergraduate students would enhance demographic representation of younger rural populations and capture a high proportion of private well users.

## 2.3 | Survey scoring protocol

Scoring protocols were devised to enable comprehensive quantification of both awareness of private well maintenance factors and risk perceptions of EWE impacts on private groundwater quality. Protocols were based, in part, on a previous scoring framework developed by Lavallee et al. (2021), which encompassed multiple aspects of supply maintenance and contamination risk. Relevant questions were assigned as "domains," with scores appended to individual response categories to form a maximum total and enable characterization of respondents based on scaled (standardized) scores.

To quantify overall awareness, dichotomous, and trichotomous scoring protocols were used across seven categories (Table 1). Risk perception of EWE impacts on private groundwater was scored based on three components, with dichotomous ordinal scoring (0–2) used for each EWE type per risk perception domain to calculate overall respondent risk perception (Table 2).

## 2.4 | Statistical analysis

SEM was selected to model well user behaviors as it enabled identification and testing of multivariate causal relationships and their directionality, thus permitting individual factor and pathway prioritization for future risk communication interventions (Barrett, 2007). Three binary behavioral outcomes were employed: seeking of well maintenance information (Y/N), prior testing of well water (Y/N), and implementation of post-EWE well maintenance actions (Y/N). These individual outcomes were selected as they were deemed to constitute key protective actions. For analysis of post-EWE actions, only respondents who reported experiencing a (named) EWE were included. Adoption of a post-EWE action

**TABLE 1** Awareness scoring framework (domains, response categories, and scoring protocols)

| Awareness domain | Response categories | | Scoring protocol | Score [a] |
|---|---|---|---|---|
| **Well age** | 0–5 years | 5–10 years | Aware | 1 |
| | 10–20 years | 20–30 years | Unaware | 0 |
| | 30–50 years | > 50 years | | |
| | Don't know | | | |
| **Well depth** | < 10 ft (3 m) | 10–50 ft (3–15 m) | Aware | 1 |
| | 50–100 ft (15–30 m) | 100–200 ft (30–60 m) | Unaware | 0 |
| | 200–300 ft (60–90 m) | > 300 ft (90 m) | | |
| | Don't know | | | |
| **Well features** [b #] | Well cap present | Cemented well casing | Aware of 5–6 features | 3 |
| | Damaged well cap | Damaged well casing | Aware of 3–4 features | 2 |
| | Pump at base of well | Buried well | Aware of 1–2 features | 1 |
| | | | Aware of 0 features | 0 |
| **Treatment system present** | Yes | No | Aware | 1 |
| | Don't know | | Unaware | 0 |
| **Previous water quality test** | Yes | No | Aware | 1 |
| | Don't know | | Unaware | 0 |
| **Pathogens found in wells** [b ǂ] | *Campylobacter* | *Cryptosporidium* | Aware of 5–6 pathogens | 3 |
| | *Giardia* | *Norovirus* | Aware of 3–4 pathogens | 2 |
| | *Salmonella* | *Verotoxigenic E.coli* | Aware of 1–2 pathogens | 1 |
| | | | Aware of 0 pathogens | 0 |
| **Pathogen sources** [b ǂ] | Domestic animals | Farmyards | Aware of 3–4 sources | 2 |
| | Grazing animals | Septic tanks | Aware of 1–2 sources | 1 |
| | | | Aware of 0 sources | 0 |

[a]Maximum awareness score = 12.
[b]Respondents required to select "Yes," "No" or "Don't know" for each category.
[#]"Yes" and "No" answer options classified as "Aware."
[ǂ]Only "Yes" answer options classified as "Aware."

**TABLE 2** Risk perception scoring framework (domains, response categories, and scoring protocols)

| Risk perception domain | Event types | Response category | Score [a] |
|---|---|---|---|
| Perceived likelihood | Drought | Unlikely | 0 |
| | Flood | Neither likely nor unlikely | 1 |
| | Heavy rainfall | Likely | 2 |
| | Snowfall | | |
| Perceived severity | Drought | Minor | 0 |
| | Flood | Moderate | 1 |
| | Heavy rainfall | Serious | 2 |
| | Snowfall | | |
| Perceived consequences [b] | Drought | Disagree | 0 |
| | Flood | Neither agree nor disagree | 1 |
| | Increased rainfall [c] | Agree | 2 |
| | Warmer temperatures [c] | | |

[a]Maximum score per risk perception domain = 8, maximum overall risk perception score = 24.
[b]Statements outlined in Appendix.
[c]Correspondent climate trends.

was predicated upon performance of ≥1 specified or unspecified actions in the aftermath of an EWE. Post-EWE actions comprised:

- Boiling water
- Carrying out a visual well inspection
- Enquiring about well safety

**TABLE 3** List of variables utilized in model parameterization phase

| Variable type | Variable theme | Individual variables | Measurement type |
|---|---|---|---|
| **Exogenous** | **Sociodemographic** | Geographic location (province) | Nominal |
| | | Gender | Dichotomous |
| | | Age | Ordinal |
| | | Presence of vulnerable household member | Dichotomous |
| | | Household size | Ordinal |
| | | Education | Ordinal |
| | | Income | Ordinal |
| | | Homeownership | Dichotomous |
| | | Residential duration | Ordinal |
| | **Supply characteristics** | Well history | Dichotomous |
| | | Well connection | Dichotomous |
| | | Well use | Dichotomous |
| | **Experiential** | Recent household history of gastrointestinal illness | Dichotomous |
| | | EWE experience | Dichotomous |
| | **Cognitive** | EWE risk perception | Standardized score |
| | | Supply awareness | Standardized score |
| | | Climate change concern | Ordinal |
| | | Confidence in maintaining supply | Ordinal |
| **Endogenous** | **Behavioral** | Information seeking | Dichotomous |
| | | Post-EWE actions | Dichotomous |
| | | Well testing history | Dichotomous |

- Switching to bottled water or an alternative domestic water source
- Testing well water
- Installing a treatment system

To minimize the number of model inputs and establish variables of key significance, stepwise regression was used for dimensionality reduction for each behavioral type prior to SEM. Stepwise regression models were subsequently evaluated for goodness of fit using the Hosmer–Lemeshow test (Hosmer et al., 2013). These analyses were undertaken in IBM SPSS Statistics 27. The list of explanatory variables considered for SEM is outlined in Table 3. Cronbach's alpha tests were conducted to evaluate internal consistency of responses to scored awareness and risk perception items before commencement of modeling.

SEM was performed using IBM SPSS AMOS 27 Graphics, with data survey data imported from IBM SPSS Statistics 27. The two domain variables utilized (supply awareness and EWE risk perception) were non-normally distributed and thus log transformed prior to analyses. SEM was selected to identify direct and indirect causal pathways between exogenous (independent) and endogenous (dependent) variables as well as directionality, that is, whether variable values rise and fall in unison (positive relationship) or move in opposite directions (negative relationship). Chi-square tests were used to discern significant deviations between the default (proposed) model and saturated (best-fitting) model, with nonsignificant results indicative of a parsimonious default model. The chi-square value for the default model was additionally compared to the value for the independence (null model), with a smaller value for the default model indicating improved model fit. While the overarching research agenda was partly guided by previous analyses of the parent survey (Mooney, O'Dwyer, Hynds, 2021; Mooney, O'Dwyer, Lavalleee et al., 2021), model development was not guided by particular hypotheses; accordingly, the path analysis model type was chosen as opposed to other forms of SEM (e.g., confirmatory factor analysis). Model beta weights were converted to odds ratios (OR), with the confidence interval was set to 95% by convention.

Maximum likelihood estimation was used for parameter estimation, with means and intercept values computed for all input variables. Both standardized and unstandardized coefficients were measured in the output, in addition to critical ratios, standard errors, and indirect and total effects. Significance of indirect and total effects was measured using the bias-corrected bootstrap percentile method (95% CI). To enable calculation of $p$ values for indirect and total effects, data were reentered following list-wise deletion to ensure no missing data. User-defined *estimands* (i.e., specified indirect pathways) were also included in model outputs to enable analysis of specific indirect pathways within each behavioral model.

Akaike's information criterion (AIC) was used to establish the best fitting model based on variable parsimony while the root mean square error of approximation (RMSEA) was used to select models based on the standard deviation of residuals (prediction errors), with smaller values preferred. According to conventional criteria, good model fit is indicated by a RMSEA $< 0.05$; the AIC of a well fit model is lower than the comparison (saturated) model (Schreiber et al., 2006). Additional indices were consulted including the Tucker–Lewis Index (TLI) and comparative fit index (CFI), with values $> 0.95$ used to indicate good model fit (Xia & Yang, 2019).

**TABLE 4** Sociodemographic and supply use characteristics of survey respondents ($n$ = 560)

| Variable | Total answered [a] | Variable categories | Frequency (%) |
|---|---|---|---|
| **Geographic location (province)** | 560 | Connacht | 60 (10.7) |
| | | Leinster | 250 (44.6) |
| | | Munster | 212 (37.9) |
| | | Ulster | 38 (6.8) |
| **Gender** [b] | 553 | Male | 293 (53.0) |
| | | Female | 260 (47.0) |
| **Age** | 560 | 18–24 years | 150 (26.8) |
| | | 25–34 years | 65 (11.6) |
| | | 35–44 years | 111 (19.8) |
| | | 45–54 years | 115 (20.5) |
| | | 55–64 years | 91 (16.3) |
| | | > 65 years | 28 (5.0) |
| **Vulnerable household member present** | 560 | Yes | 172 (30.7) |
| | | No | 388 (69.3) |
| **Household size** | 560 | Small (1–2 persons) | 121 (21.6) |
| | | Medium (3–4 persons) | 229 (40.9) |
| | | Large (≥5 persons) | 210 (37.5) |
| **Education** | 536 | Primary/secondary school | 168 (31.3) |
| | | University/vocational degree | 251 (46.8) |
| | | Postgraduate (MA/PhD) | 117 (21.8) |
| **Income** | 440 | €0–25,000 | 32 (7.3) |
| | | €25,000-50,000 | 113 (25.7) |
| | | €50,000–75,000 | 112 (25.5) |
| | | €75,000–100,000 | 92 (20.9) |
| | | > €100,000 | 91 (20.7) |
| **Homeownership** | 560 | Own | 542 (96.8) |
| | | Rent | 18 (3.2) |
| **Residential duration** | 560 | 0–10 years | 103 (18.4) |
| | | 10–20 years | 214 (38.2) |
| | | >20 years | 243 (43.4) |
| **Well construction history** | 531 | Installed by previous occupants | 220 (41.4) |
| | | Installed during current occupancy | 311 (58.6) |
| **Well connection** | 560 | Individual household | 488 (87.1) |
| | | Group water scheme | 72 (12.9) |
| **Well use** [#] | 557 | Other domestic (e.g., cooking) | 505 (90.7) |
| | | Agriculture | 284 (51.0) |
| | | No other purpose | 7 (1.3) |

[a]Chosen answer categories with < 10 responses and "opt out" clauses were excluded from analysis.
[b]Male students overrepresented due to agricultural college demographics.
[#]Supplementary to drinking water.

# 3 | RESULTS

## 3.1 | Survey completion

The survey was attempted by 765 private well users, 74.8% ($n$ = 572) of whom undertook the online survey and 25.2% ($n$ = 193) of whom undertook the physical survey. Survey responses were deemed suitable for analysis where respondents answered all questions necessary for awareness quantification and subsequent analysis. A total of 560 surveys were retained after removal of invalid responses, with respondents deriving from all 26 counties in the ROI (see Appendix). A summary of respondent sociodemographics and supply use characteristics are presented in Table 4.

## 3.2 | Respondent experiences

Over half of respondents (54.8%, $n$ = 282) reported experiencing ≥ 1 specified EWE (Table 5). The most frequently experienced event type was drought (32.6%, $n$ = 168), followed by snowfall ($n$ = 155, 30.1%), heavy rainfall (26.6%, $n$ = 137) and flood (13.0%, $n$ = 67). Well users who did not cite experience with a recent EWE were excluded from the post-EWE actions model to ensure consistency in experiential background. Occurrence of a recent episode of gastrointestinal illness in the household was reported by 13.1% ($n$ = 70) of respondents.

## 3.3 | Respondent behavior and cognitive domains

Over half of respondents ($n$ = 223) able to recall their household history of information reported a previous attempt to seek supply maintenance information (Table 6). Of the 282 respondents who reported experiencing a recent EWE, 56.7% ($n$ = 160) stated that ≥1 protective actions were undertaken in the aftermath of the event. Supply testing history was reported by a total of 520 respondents, of

**TABLE 5** Respondent EWE experience and recent household history of gastrointestinal illness

| Variable | Total answered | Variable categories | Frequency (%) |
|---|---|---|---|
| Experienced recent EWE | 515 | Yes | 282 (54.8) |
| | | No | 233 (45.2) |
| Experienced drought event | 515 | Yes | 168 (32.6) |
| | | No | 347 (67.4) |
| Experienced flood event | 515 | Yes | 67 (13.0) |
| | | No | 448 (87.0) |
| Experienced heavy rainfall | 515 | Yes | 137 (26.6) |
| | | No | 378 (73.4) |
| Experienced snowfall event | 515 | Yes | 155 (30.1) |
| | | No | 360 (69.9) |
| Household illness in last 12 months | 535 | Yes | 70 (13.1) |
| | | No | 465 (86.9) |

**TABLE 6** Adoption of well maintenance behaviors in respondent households

| Variable | Total answered | Variable categories | Frequency (%) |
|---|---|---|---|
| **Previous seeking of supply maintenance information** | 441 | Yes | 223 (50.6) |
| | | No | 218 (49.4) |
| **Previous adoption of post-EWE actions** [a] | 282 | Yes | 160 (56.7) |
| | | No | 122 (43.3) |
| **Previous well test in household** | 520 | Yes | 383 (73.7) |
| | | No | 137 (26.3) |

[a]Respondents who reported experiencing a recent EWE.

whom 73.7% ($n$ = 383) reported at least one previous well test.

Respondents exhibited a median overall supply awareness score of 66.7% (SD ± 20.7%) and a median overall EWE risk perception score of 50.0% (SD ± 22.0%). Responses to combined awareness ($\alpha$ = 0.770) and risk perception items ($\alpha$ = 0.806) showed good internal consistency across scales. Detailed analyses of awareness and risk perception score domains have been reported in Mooney, O'Dwyer, Hynds (2021) and Mooney, O'Dwyer, Lavalleee et al. (2021). In rating their concern about climate change impacts on groundwater, 54.0% ($n$ = 278) of respondents expressed concern while 30.0% ($n$ = 139) expressed neither concern nor unconcern and 19.0% ($n$ = 98) expressed no concern. With respect to confidence in maintaining supply, 39.2% ($n$ = 185) reported confidence in their ability compared to 48.1% ($n$ = 227) reporting uncertainty, and 12.7% ($n$ = 60) citing no confidence.

## 3.4 | Behavioral models

All three developed models were recursive (unidirectional) and contained a total of six parameters, with five endogenous variables (Figures 1–3). Indirect and total effects for each model are outlined in TablesA1–A9.

## 3.5 | Information seeking behavior

The developed model obtained a chi-square value of 11.281($DF$ = 9), with a nonsignificant (preferable) $p$ value of 0.257 (Table 7). Fit indices indicated good model fit relative to other trialed models: AIC = 47.281, CFI = 0.981, RMSEA = 0.021 and TLI = 0.956. Standardized and unstandardized regression coefficients (direct effects) are outlined in Table 8.

In the first of three principal pathways to information seeking, age indirectly affected respondent behavior via supply awareness ($\beta$ = 0.071, $p$ = 0.001). This pathway constituted the strongest indirect effect in the model. A one-unit increase in respondent age range was associated with a 3.1% increase in supply awareness score ($p$ < 0.001). The impact of supply awareness on information seeking behavior represented both the strongest direct and total effect in the model ($\beta$ = 0.289). A 10% increase in awareness brought about a 7.3% increase in information seeking ($p$ < 0.001) that is, a one-unit awareness increase equated to a 5.1% increase in information seeking ($p$ < 0.001) upon conversion of awareness scores to ordinal values (i.e., 0–12).

Confidence in maintaining well also indirectly influenced information seeking via supply awareness ($B$ = 0.037, $p$ = 0.001), representing the second primary pathway to

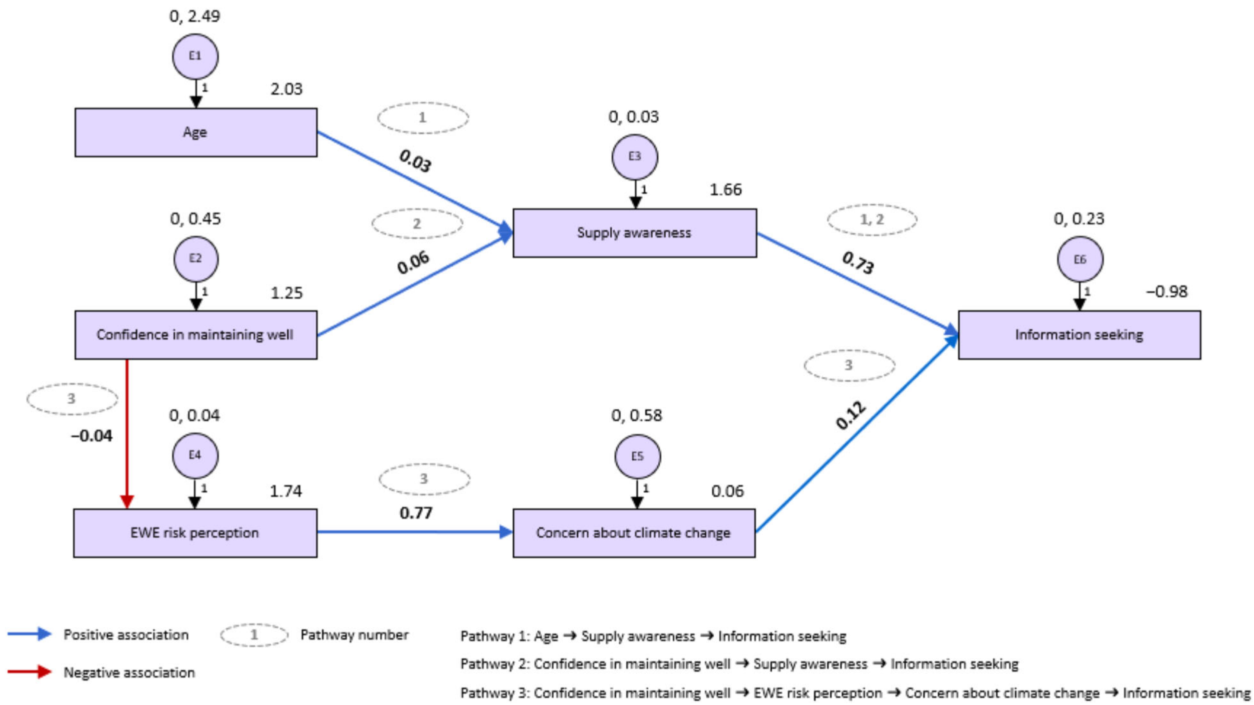


**FIGURE 1** Path diagram of information seeking model outlining unstandardized coefficients, intercept values, and error terms

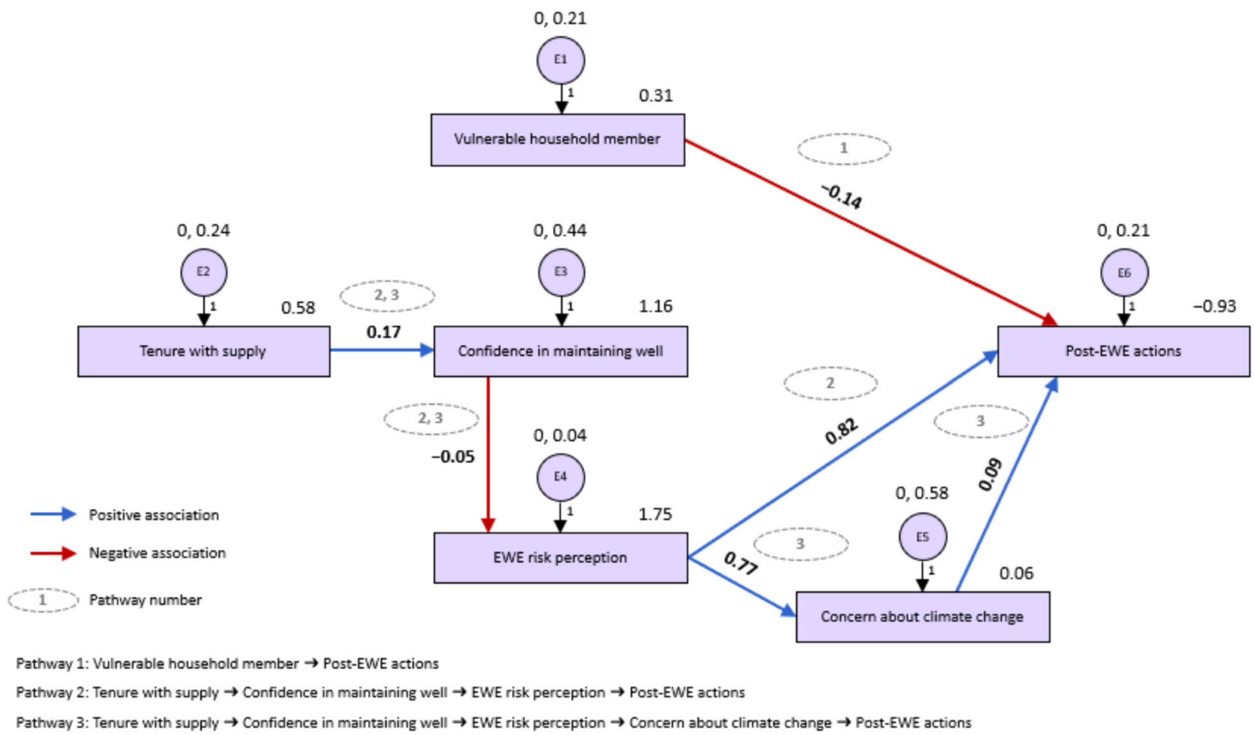


**FIGURE 2** Path diagram of post-EWE actions model outlining unstandardized coefficients, intercept values, and error terms

information seeking. With each increase in level of confidence, supply awareness increased by 6.8% ($p < 0.001$). In the third model pathway to information seeking behavior, confidence indirectly mediated information seeking through EWE risk perception and concern about climate change ($B = -0.004$, $p < 0.001$). A one-unit increase in confidence engendered a 4.8% decrease in EWE risk perception ($p < 0.001$), with a one-unit increase in EWE risk perception associated with a 3.2% increase in concern about climate change ($p < 0.001$). A 10% (raw score) increase in EWE risk

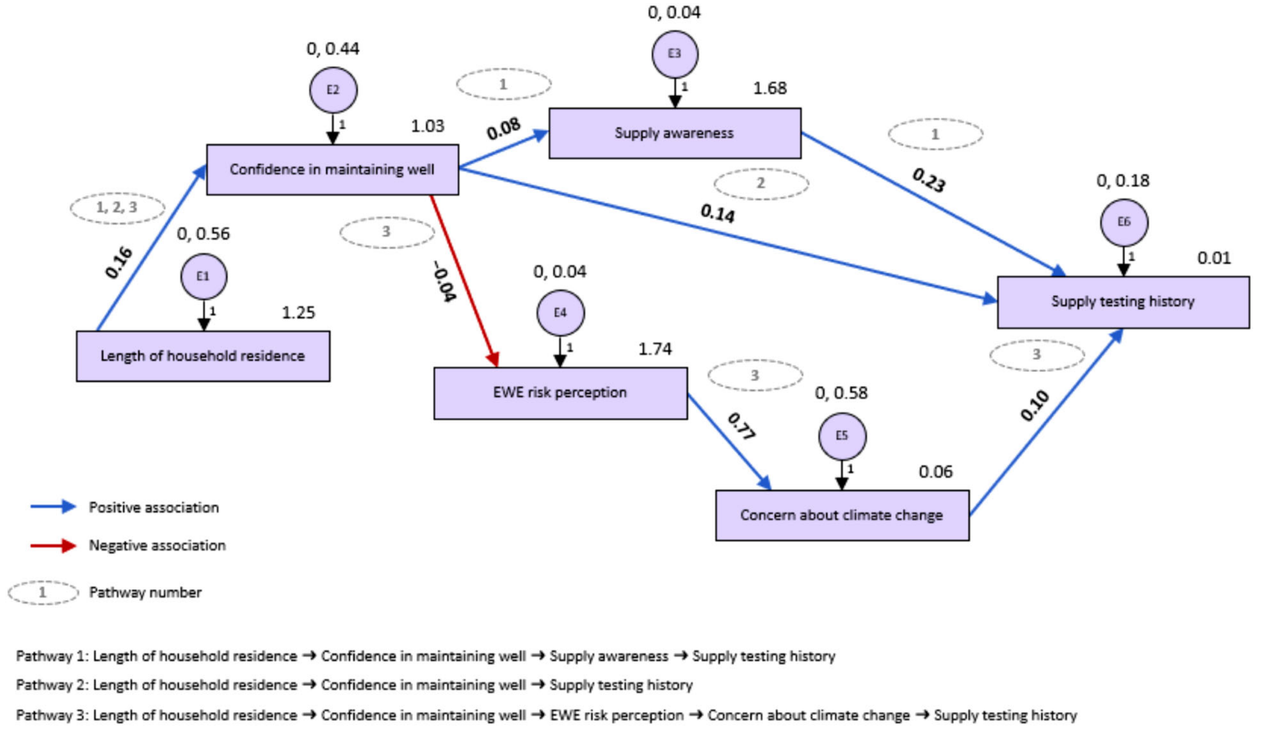


**FIGURE 3** Path diagram of supply testing model outlining unstandardized coefficients, intercept values, and error terms

**TABLE 7** Model fit indices of default, independent and saturated models

| | AIC | CFI | Chi-square | RMSEA | TLI |
|---|---|---|---|---|---|
| Default model | 45.648 | 0.995 | 9.648 | 0.011 | 0.987 |
| Independence model | 152.063 | 0.000 | 140.063 | 0.101 | 0.000 |
| Saturated model | 54.000 | 1.000 | – | – | – |

Abbreviations: AIC, Akaike's information criterion; CFI, Comparative fix index; RMSEA, Root mean square error of approximation; TLI, Tucker–Lewis Index.

**TABLE 8** Standardized and unstandardized regression coefficients in information seeking model

| Exogenous variables | | Endogenous variables | B | $\beta$ | O.R. | S.E. | C.R. | *P* value |
|---|---|---|---|---|---|---|---|---|
| Age | → | Supply awareness | 0.031 | 0.246 | 1.279 | 0.005 | 6.137 | < 0.001 |
| Concern about climate change | → | Information seeking | 0.116 | 0.179 | 1.196 | 0.029 | 3.987 | < 0.001 |
| Confidence in maintaining well | → | EWE risk perception | −0.044 | −0.141 | 0.868 | 0.014 | −3.108 | 0.002 |
| Confidence in maintaining well | → | Supply awareness | 0.068 | 0.228 | 1.256 | 0.013 | 5.290 | < 0.001 |
| EWE risk perception | → | Concern about climate change | 0.766 | 0.207 | 1.230 | 0.159 | 4.804 | < 0.001 |
| Supply awareness | → | Information seeking | 0.728 | 0.289 | 1.335 | 0.113 | 6.447 | < 0.001 |

Abbreviations: C.R., critical ratio; EWE, extreme weather event; O.R., odds ratio; S.E., standard error.

perception resulted in a 7.7% increase in concern about climate change ($p < 0.001$). Increased concern about climate change impacts on groundwater equated to an 11.6% increase in information seeking behavior ($p = 0.014$).

## 3.6 | Post-EWE actions

The default (proposed) model for adoption of post-EWE actions obtained a chi-square value of 9.180($DF = 9$) and $p$ value of 0.421, denoting good model fit. The CFI and TLI both demonstrated a fit ≥ 0.95, with a RMSEA of 0.021 also indicative of good model fit (Table 9). A smaller AIC value (45.180) for the default model suggested good model parameterization. Associational directionality and unstandardized model beta coefficients are outlined in Table 10.

Presence of a vulnerable household member constituted a singular, direct pathway to adoption of post-EWE actions, with residence of ≥1 elderly and/or infant residents in a respondent household corresponding with a 14.3% decrease

**TABLE 9** Model fit indices of default, independent, and saturated models

| | AIC | CFI | Chi-square | RMSEA | TLI |
|---|---|---|---|---|---|
| Default model | 45.180 | 0.998 | 9.180 | 0.006 | 0.994 |
| Independence model | 105.594 | 0.000 | 93.594 | 0.079 | 0.000 |
| Saturated model | 54.000 | 1.000 | – | – | – |

Abbreviations: AIC, Akaike's information criterion; CFI, Comparative fix index; RMSEA, Root mean square error of approximation; TLI, Tucker–Lewis Index.

**TABLE 10** Standardized and unstandardized regression coefficients in post-EWE actions model

| Exogenous variables | | Endogenous variables | B | *β* | O.R. | S.E. | C.R. | *P* value |
|---|---|---|---|---|---|---|---|---|
| Concern about climate change | → | Post-EWE actions | 0.088 | 0.136 | 1.146 | 0.036 | 2.452 | 0.014 |
| Confidence in maintaining well | → | EWE risk perception | −0.048 | −0.152 | 0.859 | 0.014 | −3.356 | < 0.001 |
| EWE risk perception | → | Concern about climate change | 0.766 | 0.207 | 1.230 | 0.159 | 4.804 | < 0.001 |
| EWE risk perception | → | Post-EWE actions | 0.818 | 0.343 | 1.409 | 0.132 | 6.184 | < 0.001 |
| Tenure with supply | → | Confidence in maintaining well | 0.172 | 0.126 | 1.134 | 0.063 | 2.712 | 0.007 |
| Vulnerable household member | → | Post-EWE actions | −0.143 | −0.131 | 0.877 | 0.059 | −2.416 | 0.016 |

Abbreviations: C.R., critical ratio; EWE, extreme weather event; O.R., odds ratio; S.E., standard error.

in protective behaviors ($p = 0.016$). Supply tenure (i.e., respondent residence at their home during well construction) constituted the root variable of the remaining two pathways; supply tenure indirectly affected adoption of post-EWE actions through confidence in maintaining well and EWE risk perception ($B = 0.006$, $p = 0.023$) (Pathway 2) and through climate change concern via confidence and risk perception ($B < 0.001$, $p = 0.031$) (Pathway 3).

EWE risk perception had the strongest direct ($\beta = 0.343$, $p < 0.001$) and total effect ($\beta = 0.371$, $p = 0.001$) on adoption of post-EWE actions. For every 10% increase in EWE risk perception score, adoption of post-EWE actions increased by 8.2% ($p < 0.001$) and concern about climate change by 7.7% ($p < 0.001$). When EWE risk perception scores were converted to ordinal values (i.e., 0–24), a one-unit increase in risk perception resulted in a 2.8% increase in adoption of post-EWE actions ($p < 0.001$) and 3.2% increase in climate change concern ($p < 0.001$). Confidence in maintaining well demonstrated the greatest indirect influence ($\beta = -0.057$, $p = 0.022$) on adoption of post-EWE actions; the pathway from confidence to behavior via EWE risk perception ($B = -0.030$, $p = 0.020$) exhibited a greater impact on post-EWE actions than the pathway from confidence to behavior via climate change concern ($B = -0.002$, $p = 0.040$). Confidence in maintaining well was 17.2% higher ($p = 0.007$) among private well users who resided at their current property at the time of well construction. However, increased confidence in maintaining well inversely influenced EWE risk perception, with respondent risk perception score decreasing by 4.9% ($p < 0.001$) for every increase in confidence level.

### 3.6.1 | Supply testing history

The default (proposed) model obtained an appropriate chi-square value of 11.044($DF = 8$), and $p$ value of 0.199. All comparative fit indices demonstrated an appropriate fit ≥ 0.9, with CFI exceeding the desired value of 0.95 and the AIC value of 49.044 for the default model indicating good model parameterization (Table 11). Structural relationships are displayed in the model path diagram (Figure 3).

Length of household residence functioned as the root variable for all three model pathways to supply testing (Figure 3) and had the strongest indirect influence on supply testing ($\beta = 0.048$, $p = 0.001$). For every one-unit (i.e., 10-year) increase in length of residence at household, confidence in maintaining well rose by 16.3% ($p < 0.001$). A $B$ value (0.163) and confidence intercept value (1.033) suggest that the impact of length of residence on supply confidence is lesser than the impact of supply tenure in the previous model for post-EWE actions (Table 12). Each pathway diverged independently from confidence, which demonstrated both the greatest direct ($\beta = 0.222$, $p < 0.001$) and total effect ($\beta = 0.245$, $p < 0.001$) on supply testing.

For pathway 1, length of household residence indirectly affected supply testing via confidence and supply awareness ($B = 0.002$, $p = 0.031$). Each increase in confidence level increased supply awareness by 8.1% ($p < 0.001$). The impact of confidence on awareness in this model was greater than the impact of age and confidence on awareness in the information seeking model, with the variance value (1.676) indicating a higher baseline where respondents cited no confidence. A 10% increase in awareness score resulted in a 2.3% increase in supply testing ($p = 0.017$). For pathway 2, length of household residence indirectly affected supply testing via confidence in maintaining well ($B = 0.021$, $p = 0.001$). Each increase in confidence level resulted in a 14.5% increase in previous supply testing ($p < 0.001$).

The indirect impact of length of residence on testing via confidence, EWE risk perception, and climate concern (pathway 3) was also significant ($B = -0.001$, $p = 0.001$). Similar to the preceding two models, confidence negatively

**TABLE 11** Model fit indices of default, independent, and saturated models

| | AIC | CFI | Chi-square | RMSEA | TLI |
|---|---|---|---|---|---|
| Default model | 49.044 | 0.972 | 11.044 | 0.026 | 0.927 |
| Independence model | 142.209 | 0.000 | 130.209 | 0.096 | 0.000 |
| Saturated model | 54.000 | 1.000 | – | – | – |

Abbreviations: AIC, Akaike's information criterion; CFI, Comparative fix index; RMSEA, Root mean square error of approximation; TLI, Tucker–Lewis Index.

**TABLE 12** Standardized and unstandardized regression coefficients in supply testing model

| Exogenous variables | | Endogenous variables | B | β | O.R. | S.E. | C.R. | P value |
|---|---|---|---|---|---|---|---|---|
| Concern about climate change | → | Supply testing history | 0.098 | 0.173 | 1.189 | 0.025 | 3.993 | < 0.001 |
| Confidence in maintaining well | → | EWE risk perception | −0.043 | −0.138 | 0.871 | 0.014 | −3.043 | 0.002 |
| Confidence in maintaining well | → | Supply awareness | 0.078 | 0.268 | 1.307 | 0.013 | 6.121 | < 0.001 |
| Confidence in maintaining well | → | Supply testing history | 0.145 | 0.222 | 1.249 | 0.030 | 4.801 | < 0.001 |
| EWE risk perception | → | Concern about climate change | 0.765 | 0.207 | 1.230 | 0.159 | 4.801 | < 0.001 |
| Length of household residence | → | Confidence in maintaining well | 0.163 | 0.179 | 1.196 | 0.041 | 3.993 | < 0.001 |
| Supply awareness | → | Supply testing history | 0.232 | 0.104 | 1.110 | 0.098 | 2.376 | 0.017 |

Abbreviations: C.R., critical ratio; EWE, extreme weather event; O.R., odds ratio; S.E., standard error.

(inversely) influenced EWE risk perception ($B = -0.138$, $p = 0.002$); increased confidence resulted in a 4.3% decrease in EWE risk perception score. For every 10% increase in risk perception score, concern about climate change rose by 7.7% while an ordinal increase in risk perception score elicited a 3.2% increase in climate change concern. Concern about climate change positively influenced supply testing, resulting in a 9.8% increase in testing for each rise in concern ($p < 0.001$).

## 4 | DISCUSSION

The primary difference between private and public municipal supplies is regulation, resulting in a situation whereby private well users/owners represent both a source and receptor of supply contamination. Maintenance information, adoption of post-EWE protective measures and routine well water testing represent three vital strands to mitigating private well contamination risk. Obtainment of maintenance information is meanwhile integral as increased frequency of EWEs will necessitate additional knowledge of supply management measures and their recommended frequency (e.g., water quality testing). However, existing behavioral interventions have accomplished only marginally improved behaviors (Mooney et al., 2020a). In order to develop empirically informed, tailored private groundwater risk interventions, it is essential that key underlying structural relationships underpinning supply maintenance behaviors are identified. As the existing evidence base largely overlooks the role of climate change beliefs and well user confidence in maintaining their supply, a wider conception of latent, cognitive variables such as perceived self-efficacy is necessary. Utilizing data from a survey of 560 Irish private well users, the authors employed SEM to identify interrelationships underpinning predictors of three private well maintenance actions.

### 4.1 | Information seeking behavior

In the absence of concerted private groundwater risk interventions, passive information channels for private well users such as government websites and hotlines represent the main apparatus for risk communication in most regions (Fox et al., 2016; Ridpath et al., 2016). In light of concerns around the utility of existing water quality guidance, factors underlying information seeking behaviors are of critical importance (Khan et al., 2015). The three pathways within the information seeking behavior model developed in the current study suggest that knowledge and confidence lie at the center of information seeking behavior.

The positive relationship between age and supply awareness may be attributed to an increased likelihood of household information acquisition over the lifespan of a supply. The significant association between increased supply awareness and, in turn, information seeking behavior among older well users suggests that younger well users may not be inclined to pursue supply knowledge until they assume responsibility as household heads. Higher awareness levels among older well users have been found in previous studies, both in Ireland and further afield (Colley et al., 2019; Hynds et al., 2018b; Naughton & Hynds, 2014). A survey of well users undertaken by Hynds et al. (2014) in the ROI between 2008–2010 discerned markedly lower levels of supply awareness among student age well users than adult well users across multiple categories including knowledge of well records ($p < 0.001$), well treatment ($p < 0.001$), and testing frequency ($p < 0.001$). This would indicate a longstanding trend with respect to age and supply knowledge acquisition and represents a potentially important intervention control point as greater supply knowledge at a younger age may reduce inconvenience further downstream.

Higher perceived self-efficacy (i.e., confidence) also positively predicted supply awareness ($p < 0.001$), with higher levels of confidence indirectly influencing information seeking behavior via awareness. However, an additional (indirect) pathway to information seeking behavior was identified among respondents displaying lower levels of confidence. There was a significant negative relationship between confidence and EWE risk perception ($p = 0.002$), the latter of which positively influences information seeking via concern about climate change. This pathway distinguishes a cohort of climate conscious well users who have previously sought out maintenance information yet display lower levels of self-perceived confidence. This finding signals both a self-perceived lack of information concerning climate change adaptation measures relevant to well maintenance and a greater willingness among climate conscious well users to seek out well maintenance information. The significant role of perceived self-efficacy in this context is corroborated by literature examining other forms of health-associated information seeking behavior (Ahn & Noh, 2020; Yang et al., 2014). Kahlor's (2010) *PRISM* (Planned Risk Information Seeking Model) model places perceived self-efficacy at the center of risk information seeking decisions. Kahlor's model regards self-efficacy as a multifaceted concept—involving perceived risk control, perceived risk knowledge, and perceived utility of information sought. As the current model denotes perceived *behavioral* ability on the part of well users, a wider conceptualization of self-efficacy including constructs such as perceived control (defined as the extent to which individuals consider themselves capable of adequately managing their behavior and external factors such as weather or resource availability) represents a future research agenda relating to private wells (Infurna & Reich, 2016). While relating exclusively to physical private well maintenance as opposed to supply risk information seeking, the role of perceived control in determining well user maintenance behavior has been distinguished as a significant variable by Schuitema et al. (2020) in another recent survey of Irish well users. As such, a multidimensional conception of behavioral efficacy extending toward the perceived efficacy of supply management actions may be required in future studies examining well user behavior.

## 4.2 | Post-EWE actions

Structural relationships underpinning likelihood of adopting post-EWE actions were more distinct than those determining information seeking behavior and supply testing behavior. The model distinguished a direct predictive pathway based on a distinct sociodemographic variable (presence of a vulnerable household member) and an indirect pathway mediated by household tenure during supply construction and self-perceived confidence in maintaining supply.

The negative influence of presence of a vulnerable household member on adoption of post-EWE actions and ($p = 0.016$) indicates the importance of sociodemographic factors (and potential physiological and cognitive capabilities) in the face of extreme weather and is cause for appreciable public health concern. The absence of post-EWE actions among elderly well users may also be explained by knowledge gaps relating to EWE impacts on groundwater quality. This finding is reinforced by previous behavioral and cognitive studies noting lower levels of climate change adaptation and risk perception among elderly populations (Akerlof et al., 2015; Brink & Wamsler, 2019). Akerlof et al. (2015) suggests that climate change-related risks to human health may appear too far in the future to resonate with elderly populations. As such, greater awareness relating to supply status and maintenance among older well users does not necessarily correspond with knowledge of context-dependent (e.g., EWE-based) risk mitigation requirements—mirroring results from the supply testing model. Notwithstanding, the urgency for enhanced engagement with vulnerable elderly populations both in the ROI and elsewhere is heightened by findings from the current study (Ahern & Hine, 2015; Weinhold & Gurtner, 2014). Increased attention towards households with young children may also be warranted. While previous Irish research has identified higher rates of well stewardship among young families (e.g., increased likelihood of having a domestic water treatment system) (Hynds et al., 2013), findings from the current study suggests that post-EWE risk mitigation may not be granted the same level of attention as other supply management measures. Where attempting to communicate such information to vulnerable populations, provision of supply maintenance and risk information and health centers and physician clinics may represent a strand of future well owner engagement policies.

Higher perceived self-efficacy in maintaining supply among respondents present on their property during well construction suggests that greater familiarity with supply and/or presence of well owners on-property during the well construction phase is beneficial. This supposition is reinforced by a recent Canadian study, which discerned positive relationships between supply awareness, risk perception, and long-term residence (Lavallee et al., 2021). Communication- and policy-based initiatives targeting both current and prospective well owners during the installation and/or rehabilitation phases of existing supplies may be useful toward reducing inaccurate beliefs and perceptions regarding well water quality. As well owners may have developed an immunity to certain waterborne illnesses or never received a negative water quality test result, they may be less inclined to perceive risks and take action (Jones et al., 2006; Lavallee et al., 2021. While private water vendors and well drilling contractors may appear best equipped to communicate maintenance and risk information upon supply installation, it is notable that there is currently no licensing procedure or statutory regulation governing private groundwater abstraction in the ROI. As such, information reliability must be taken into account where attempting to involve or recommend liaisons with well drillers as part of a communication strategy. As regulatory measures such as well driller licensing procedures and mandatory well water testing during real estate transactions are available in Scotland and certain regions within the United States, it is crucial that communicators are cognizant of potential avenues for policy change opportunities (Ablah et al., 2020; Lilly et al., 2008).

The reoccurrence of an inverse relationship between self-perceived confidence and EWE risk perception reinforces the role of self-efficacy as a mediating factor in well user behaviors, again indicating that self-reported confidence may not necessarily translate to undertaking protective behaviors among some well user cohorts. The role of perceived self-efficacy in risk mitigation behaviors has been covered extensively within the flood literature and distinguished as a central factor governing risk responses (Bubeck et al., 2013; Kuhlicke et al., 2020). As pluvial flooding driven by EWEs constitutes a significant risk factor for private groundwater contamination (Boudou et al., 2021), increased attention toward participants' self-perceived confidence in their ability to protect their supply and/or avoid exposure to waterborne contaminants, in addition to the utility of the tasks themselves may be of significant consequence. The positive relationship influence of risk perception on post-EWE actions ($p < 0.001$) further indicates that high self-perceived behavioral efficacy may in certain cases constitute an impediment to appropriate behaviors.

## 4.3 | Supply testing behavior

The developed model for supply testing behavior exhibited significant similarities with the model for supply information seeking behavior. The pathway commencing with length of household tenure and terminating at the dependent variable via perceived self-efficacy and supply awareness once again suggests that older well users characterized by high perceived security of supply and supply awareness are more likely to have tested their wells at least once. Awareness has been demonstrated to constitute an antecedent to well testing in both Canada and the United States (Colley et al., 2019; Munene & Hall, 2019), thus concerted attention toward younger well users and emergent rural homeowners constitutes an important factor in future private groundwater risk communication interventions at the point of household property sale and inheritance. A number of interventions aimed towards parents of young children have been piloted over the last decade (Murray et al., 2020; Straub & Leahy, 2014) demonstrating that measures such as reminder cues and incentivized well testing may lead to greater rates of testing among this cohort.

In contrast to the other two models, the role of self-perceived confidence in the context of supply testing was direct. The directness of this relationship likely results from well testing being seen as a single, more familiar maintenance action (in contrast to post-EWE actions). Well users who have previously tested their well once or sparingly have been shown to display a false sense of security (Imgrund et al., 2011; Lavallee et al., 2021). As such, the role of confidence is this instance may be misplaced and based on little empiric evidence. The positive (direct) impact of concern about climate change on supply testing ($p < 0.001$) has yet to be reinforced elsewhere in the literature in the context of private groundwater given the absence of similar studies. However, concern about climate change has been demonstrated to positively impact health risk behaviors among rural populations in other contexts. A recent study undertaken by Li et al. (2021) in rural China demonstrated that heightened concern about the severity of climate change positively influenced their health risk management decisions via heightened perceived access to risk management information ($p < 0.001$) and resources ($p < 0.001$). Public engagement pathways and/or platforms with a concerted focus on climate change and EWE impacts may thus be of potential utility for risk communication—particularly where indirect impacts of meteorological fluctuations are concerned.

## 4.4 | Study limitations

The current study was characterized by a number of limitations that bear consideration when interpreting study findings. As binary dependent variables were predicated on adoption or nonadoption of a behavior as opposed to frequency of behavior, presented models do not represent the full extent of protective behaviors over time. The authors also draw attention to potential recall bias in terms of EWE experience as respondents may be more inclined to disregard less recent events despite their status as EWEs. A notably larger proportion of respondents recalled the most EWE type (i.e., drought) included in the survey compared to other EWE event types. While respondents derived from all 26 counties in the ROI, respondents were overwhelmingly located in the south of the country (i.e., the province of Munster). Male respondents aged 18–24, respondents with a third-level education and respondents above the median annual income bracket were additionally overrepresented. A degree of response bias may also be present among younger populations due to lack of familiarity with private well maintenance as a household risk mitigation measure.

An additional limitation derives from the absence of applied theory in modeling selected behaviors. While it was not the attention of the authors to validate behavioral or perceptual theories, the absence of integrated theory (e.g., *Protection Motivation Theory*) somewhat limits transferability of study findings.

## 5 | CONCLUSION

Perceived self-efficacy (i.e., confidence) in maintaining supply constituted a significant predicting mediator variable for all three behavioral outcomes examined. While multiple cognitive and/or perceptual variables were present in each model, respondent age and presence of vulnerable household member represented the sole demographic variables for predicting both information seeking behavior and post-EWE actions. As such, awareness, risk perception, perceived self-efficacy, and climate change concern warrant attention in future studies relating to well user behaviors. The significant (albeit indirect) influence of EWE risk perception on both information seeking and testing behavior in addition to post-EWE actions would suggest that climate related variables are of key concern. Reduced likelihood of adoption of post-EWE actions in households with a vulnerable resident represents a cause for concern given the increased incidence of AGI associated with private well water exposure. Assessments of rural vulnerability are of significant human health importance in the face of increasing of EWES, with this finding reinforcing the susceptibility of rural homeowners to both direct and indirect effects of climate change. Significantly, the impacts of respondent age and presence on residence during supply installation on well management actions are mediated by cognitive factors, with perceived-self efficacy in maintaining supply lying at the heart of well user decision making. As such further research exploring distinct aspects of confidence (e.g., perceived risk control, physical capability, and efficacy of recommended behaviors) is recommended to discern additional potential pathways to supply maintenance behavior. Interventions clearly elucidating the efficacy of periodic supply testing, treatment and inspection and assisting elderly residents and parents of young children may be of considerable future value in ensuring that vulnerable populations are more, not less, apprised of contamination risks.

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## CONFLICT OF INTEREST

The authors can confirm that they have no commercial or other associations that might pose a conflict of interest with the presented study.

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## APPENDIX

### Indirect and total effects including user-defined estimands (specified pathways)

### Information seeking behavior

Appendix, A1-A13.

**TABLE A1** Indirect effects

| Exogenous variables | | Endogenous variables | B | *p* Value | β | *p* Value |
|---|---|---|---|---|---|---|
| Age | → | Information seeking | 0.023 | 0.001 | 0.071 | 0.001 |
| Confidence in maintaining well | → | Concern about climate change | −0.034 | 0.001 | −0.029 | 0.001 |
| Confidence in maintaining well | → | Information seeking | 0.045 | 0.001 | 0.061 | 0.001 |
| EWE risk perception | → | Information seeking | 0.089 | 0.001 | 0.037 | 0.001 |

Abbreviation: EWE, extreme weather event.

**TABLE A2** Total effects

| Exogenous variables | | Endogenous variables | B | *p* Value | β | *p* Value |
|---|---|---|---|---|---|---|
| Age | → | Information seeking | 0.023 | 0.001 | 0.071 | 0.001 |
| Age | → | Supply awareness | 0.031 | 0.002 | 0.246 | 0.002 |
| Concern about climate change | → | Information seeking | 0.116 | 0.001 | 0.179 | 0.001 |
| Confidence in maintaining well | → | Concern about climate change | −0.034 | 0.001 | −0.029 | 0.001 |
| Confidence in maintaining well | → | EWE risk perception | −0.044 | 0.001 | −0.141 | 0.001 |
| Confidence in maintaining well | → | Information seeking | 0.045 | 0.001 | 0.061 | 0.001 |
| Confidence in maintaining well | → | Supply awareness | 0.068 | 0.001 | 0.228 | 0.001 |
| EWE risk perception | → | Concern about climate change | 0.766 | 0.001 | 0.207 | 0.001 |
| EWE risk perception | → | Information seeking | 0.089 | 0.001 | 0.037 | 0.001 |
| Supply awareness | → | Information seeking | 0.728 | 0.001 | 0.289 | 0.001 |

Abbreviation: EWE, extreme weather event.

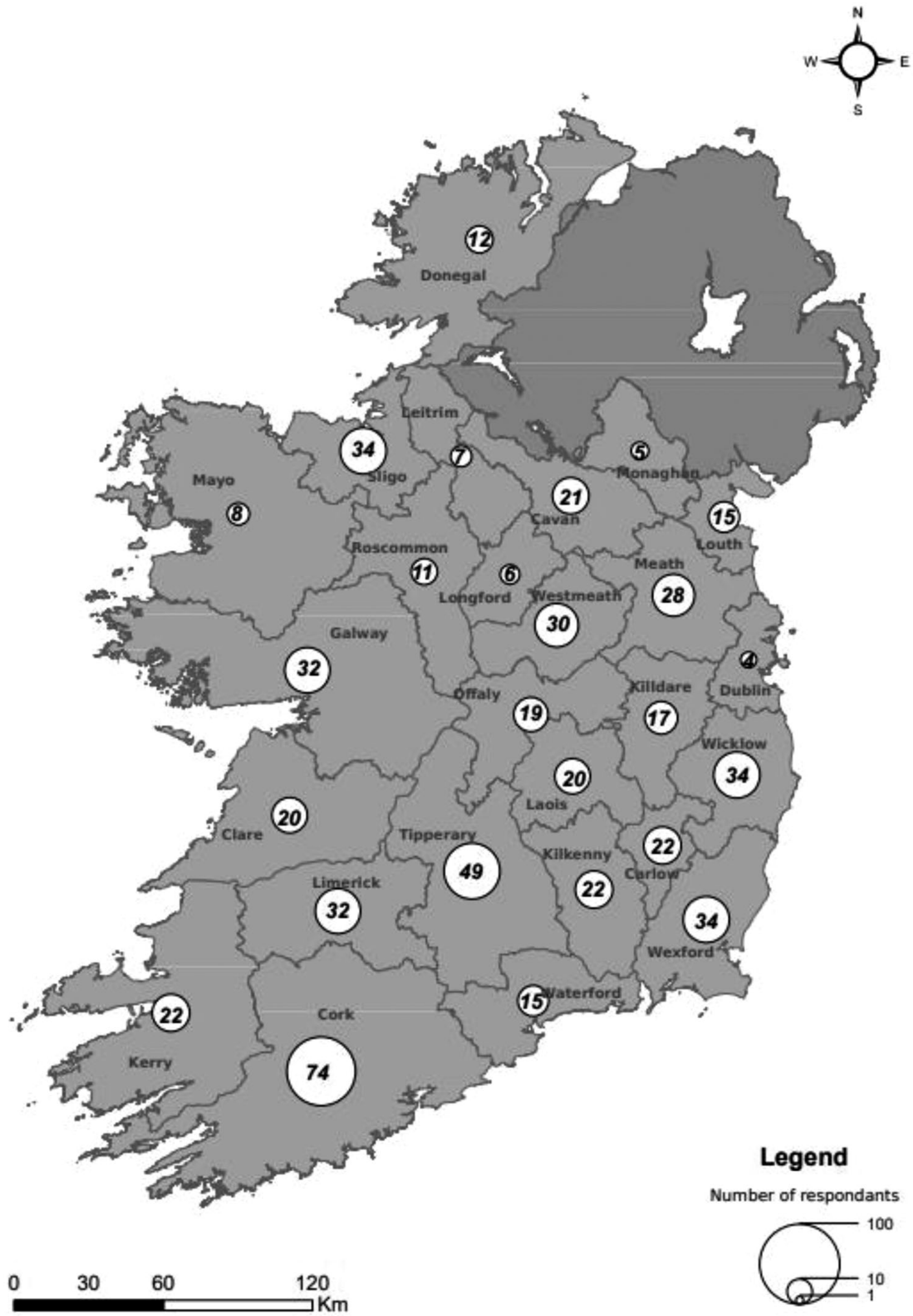


**FIGURE A1** Map of survey respondents by county in the ROI ($n = 560$)

**TABLE A3** User-defined estimands

| Pathway | B | *p* Value |
|---|---|---|
| Confidence in maintaining well → Supply awareness → Information seeking | 0.037 | 0.001 |
| Confidence in maintaining well → EWE risk perception → Concern about climate change → Information seeking | −0.004 | 0.002 |

Abbreviation: EWE, extreme weather event.

**TABLE A4** Indirect effects

| Exogenous variables | | Endogenous variables | B | *p* Value | *β* | *p* Value |
|---|---|---|---|---|---|---|
| Confidence in maintaining well | → | Concern about climate change | −0.037 | 0.048 | −0.032 | 0.048 |
| Confidence in maintaining well | → | Post-EWE actions | −0.042 | 0.022 | −0.057 | 0.022 |
| EWE risk perception | → | Post-EWE actions | 0.067 | 0.046 | 0.028 | 0.044 |
| Supply tenure | → | Concern about climate change | −0.006 | 0.035 | −0.004 | 0.039 |
| Supply tenure | → | EWE risk perception | −0.008 | 0.027 | −0.019 | 0.027 |
| Supply tenure | → | Post-EWE actions | −0.007 | 0.023 | −0.007 | 0.024 |

Abbreviation: EWE, extreme weather event.

**TABLE A5** Total effects

| Exogenous variables | | Endogenous variables | B | *p* Value | *β* | *p* Value |
|---|---|---|---|---|---|---|
| Concern about climate change | → | Post-EWE actions | 0.088 | 0.024 | 0.136 | 0.022 |
| Confidence in maintaining well | → | Concern about climate change | −0.037 | 0.048 | 0.032 | 0.048 |
| Confidence in maintaining well | → | EWE risk perception | −0.048 | 0.025 | −0.152 | 0.025 |
| Confidence in maintaining well | → | Post-EWE actions | −0.042 | 0.022 | −0.057 | 0.022 |
| EWE risk perception | → | Concern about climate change | 0.766 | 0.059 | 0.207 | 0.055 |
| EWE risk perception | → | Post-EWE actions | 0.885 | 0.001 | 0.371 | 0.001 |
| Tenure with supply | → | Concern about climate change | −0.006 | 0.035 | −0.004 | 0.039 |
| Tenure with supply | → | Confidence in maintaining well | 0.172 | 0.022 | 0.126 | 0.023 |
| Tenure with supply | → | EWE risk perception | −0.008 | 0.027 | −0.019 | 0.027 |
| Tenure with supply | → | Post-EWE actions | −0.007 | 0.023 | −0.007 | 0.024 |
| Vulnerable household member | → | Post-EWE actions | −0.143 | 0.013 | −0.131 | 0.012 |

Abbreviation: EWE, extreme weather event.

**TABLE A6** User-defined estimands

| Pathway | B | *p* Value |
|---|---|---|
| Confidence in maintaining well → EWE risk perception → Concern about climate change → Post-EWE actions | −0.002 | 0.040 |
| Confidence in maintaining well → EWE risk perception → Post-EWE actions | −0.030 | 0.020 |
| Tenure with supply → Confidence in maintaining well → EWE risk perception → Concern about climate change → Post-EWE actions | < 0.001 | 0.031 |
| Tenure with supply → Confidence in maintaining well → EWE risk perception → Post-EWE actions | 0.006 | 0.023 |

Abbreviation: EWE, extreme weather event.

**TABLE A7** Indirect effects

| Exogenous variables | | Endogenous variables | B | *p* Value | *β* | *p* Value |
|---|---|---|---|---|---|---|
| Confidence in maintaining well | → | Concern about climate change | −0.033 | 0.001 | −0.029 | 0.001 |
| Confidence in maintaining well | → | Supply testing history | 0.015 | 0.173 | 0.023 | 0.169 |
| EWE risk perception score | → | Supply testing history | 0.075 | 0.001 | 0.036 | 0.001 |
| Length of household residence | → | Concern about climate change | −0.005 | 0.001 | −0.005 | 0.001 |
| Length of household residence | → | EWE risk perception | −0.007 | 0.001 | −0.025 | 0.001 |
| Length of household residence | → | Supply awareness | 0.013 | 0.001 | 0.048 | 0.001 |
| Length of household residence | → | Supply testing history | 0.026 | 0.001 | 0.044 | 0.001 |

Abbreviation: EWE, extreme weather event.

**TABLE A8** Total effects

| Exogenous variables | | Endogenous variables | B | *p* Value | *β* | *p* Value |
|---|---|---|---|---|---|---|
| Concern about climate change | → | Supply testing history | 0.098 | 0.001 | 0.173 | 0.001 |
| Confidence in maintaining well | → | Concern about climate change | −0.033 | 0.001 | −0.029 | 0.001 |
| Confidence in maintaining well | → | EWE risk perception | −0.043 | 0.002 | −0.138 | 0.002 |
| Confidence in maintaining well | → | Supply awareness | 0.078 | 0.001 | 0.268 | 0.001 |
| Confidence in maintaining well | → | Supply testing history | 0.160 | 0.001 | 0.245 | 0.001 |
| EWE risk perception | → | Concern about climate change | 0.765 | 0.001 | 0.207 | 0.001 |
| EWE risk perception | → | Supply testing history | 0.075 | 0.001 | 0.036 | 0.001 |
| Length of household residence | → | Concern about climate change | −0.005 | 0.001 | −0.005 | 0.001 |
| Length of household residence | → | Confidence in maintaining well | 0.163 | 0.001 | 0.179 | 0.001 |
| Length of household residence | → | EWE risk perception | −0.007 | 0.001 | −0.025 | 0.001 |
| Length of household residence | → | Supply awareness | 0.013 | 0.001 | 0.048 | 0.001 |
| Length of household residence | → | Supply testing history | 0.026 | 0.001 | 0.044 | 0.001 |
| Supply awareness | → | Supply testing history | 0.232 | 0.062 | 0.104 | 0.054 |

Abbreviation: EWE, extreme weather event.

**TABLE A9** User-defined estimands

| Pathway | B | *p* Value |
|---|---|---|
| Confidence in maintaining well → EWE risk perception → Concern about climate change → Supply testing history | −0.004 | 0.001 |
| Confidence in maintaining well → Supply awareness → Supply testing history | 0.014 | 0.041 |
| Length of household residence → Confidence in maintaining well → EWE risk perception → Concern about climate change → Supply testing history | −0.001 | 0.001 |
| Length of household residence → Confidence in maintaining well → Supply awareness → Supply testing history | 0.002 | 0.031 |
| Length of household residence → Confidence in maintaining well → Supply testing history | 0.021 | 0.001 |

Abbreviation: EWE, extreme weather event.

**Post-EWE actions**
**Supply testing history**
**Survey**
**Section 1: Sociodemographics and supply characteristics**

1. Which of the following sources does your household use for drinking water?

| | |
|---|---|
| Private well | ☐ |
| Private group water scheme | ☐ |
| Public group water scheme | ☐ |
| Public (mains) supply | ☐ |
| Other | ☐ |
| Don’t know | ☐ |

If respondent does not select “Private well” or “Private group water scheme,” survey ends here.

2. In which Irish county do you currently live?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Antrim | ☐ | Down | ☐ | Leitrim | ☐ | Roscommon | ☐ |
| Armagh | ☐ | Dublin | ☐ | Limerick | ☐ | Sligo | ☐ |
| Carlow | ☐ | Fermanagh | ☐ | Longford | ☐ | Tipperary | ☐ |
| Cavan | ☐ | Galway | ☐ | Louth | ☐ | Tyrone | ☐ |
| Clare | ☐ | Kerry | ☐ | Mayo | ☐ | Waterford | ☐ |
| Cork | ☐ | Kildare | ☐ | Meath | ☐ | Westmeath | ☐ |
| Derry | ☐ | Kilkenny | ☐ | Monaghan | ☐ | Wexford | ☐ |
| Donegal | ☐ | Laois | ☐ | Offaly | ☐ | Wicklow | ☐ |

3. What is your gender?

| | |
|---|---|
| Male | ☐ |
| Female | ☐ |
| Other | ☐ |
| Prefer not to say | ☐ |

4. How old are you?

| | | | |
|---|---|---|---|
| 18–24 | ☐ | 55–64 | ☐ |
| 25–34 | ☐ | 65+ | ☐ |
| 35–44 | ☐ | Prefer not to say | ☐ |
| 45–54 | ☐ | | |

5. Including yourself, how many people within the following age groups live in your household? (please enter a number in each box)
Please enter 0 where there are no individuals in a particular age group.

| | |
|---|---|
| Infants (<1 year) | ☐ |
| Children (1–5) | ☐ |
| Children (6–10) | ☐ |
| Children (11–17) | ☐ |
| Adults (18–65) | ☐ |
| Adults (>65 years) | ☐ |

6. What is the highest educational qualification you have attained?

| | | | |
|---|---|---|---|
| No formal education | ☐ | Degree | ☐ |
| Primary level | ☐ | Masters | ☐ |
| Secondary level | ☐ | PhD | ☐ |
| Technical/vocational | ☐ | Prefer not to say | ☐ |

7. What is your annual household income (before taxes)?

| | | | |
|---|---|---|---|
| €0–€25,000 | ☐ | €100,000–125,000 | ☐ |
| €25,000–50,000 | ☐ | €125,000+ | ☐ |
| €50,000–75,000 | ☐ | Prefer not to say | ☐ |
| €75,000–100,000 | ☐ | | |

8. Does your household own or rent the residence served by your well?

| | |
|---|---|
| Own | ☐ |
| Rent | ☐ |

9. Were you living at your current residence when your well was built?

| | |
|---|---|
| Yes | ☐ |
| No (well was previously constructed) | ☐ |
| Don't know | ☐ |

10. For how many years have you lived at your current residence?

| | |
|---|---|
| 0–5 | ☐ |
| 5–10 | ☐ |
| 10–20 | ☐ |
| 20–30 | ☐ |
| 30+ | ☐ |

11. For what purpose(s) other than drinking do you use your well water? (tick all that apply)

| | |
|---|---|
| Domestic (e.g., bathing, cooking, dishwashing) | ☐ |
| Agriculture/irrigation | ☐ |
| Commercial/industrial | ☐ |
| No other purpose | ☐ |
| Don't know | ☐ |

**Section 2: Supply testing and maintenance knowledge**

12. Approximately how old is your well?

| **Scored variable: Knowledge of well age** | | | | |
|---|---|---|---|---|
| 0–5 years | ☐ | 30–50 years | ☐ | **Score** |
| 5–10 years | ☐ | 50+ years | ☐ | Aware: 1 |
| 10–20 years | ☐ | Don't know | ☐ | Unaware: 0 |
| 20–30 years | ☐ | | | |

13. Approximately how deep is your well?

**Scored variable: Knowledge of well depth**

| Feet | Meters | | **Score** |
|---|---|---|---|
| ≤10 | ≤3 | ☐ | Aware: 1 |
| 10–50 | 3–15 | ☐ | Unaware: 0 |
| 50–100 | 15–30 | ☐ | |
| 100–200 | 30–60 | ☐ | |
| 200–300 | 60–90 | ☐ | |
| 300+ | 90+ | ☐ | |
| Don't know | | ☐ | |

14. Please describe the state of your well.

| Scored variable: Knowledge of well status | | | | |
|---|---|---|---|---|
| | Yes | No | Don't know | **Score** |
| Cracked/damaged well cap[a] | ☐ | ☐ | ☐ | Aware of 5–6 details: 3 |
| Cracked/damaged well casing[b] | ☐ | ☐ | ☐ | Aware of 3–4 details: 2 |
| Well cap present | ☐ | ☐ | ☐ | Aware of 1–2 details: 1 |
| Buried well (e.g., well cap is underground) | ☐ | ☐ | ☐ | Aware of 0 details: 0 |
| Cement well casing | ☐ | ☐ | ☐ | |
| Well pump situated at bottom of well | ☐ | ☐ | ☐ | |

[a] Well cap: the well cap is the cover that is installed on top of the well casing.
[b] Well casing: the well casing is the piping that lines the interior of the well.

15. How is your wastewater managed?

| Scored variable: Knowledge of wastewater treatment | | |
|---|---|---|
| Septic tank | ☐ | **Score** |
| Public sewage | ☐ | Aware: 1 |
| Other | ☐ | Unaware: 0 |
| Don't know | ☐ | |

16. Excluding jug/cartridge filters and water softeners[a], do you use a treatment system for your well water?

| Scored variable: Knowledge of well water treatment | | |
|---|---|---|
| Yes | ☐ | **Score** |
| No | - | Aware: 1 |
| Don't know | ☐ | Unaware: 0 |

[a] These will remove certain substances and reduce hardness of water but will not treat microbial contaminants.

17. Have you ever had your well water tested for contamination?

| Scored variable: Knowledge of well water treatment | | |
|---|---|---|
| Yes | ☐ | **Score** |
| No | ☐ | Aware: 1 |
| Don't know | ☐ | Unaware: 0 |

Respondents selecting "No" or "Don't know" instructed to skip Questions 18–20.
Respondents selecting "Yes" instructed to skip Question 21.
18. Approximately how often do you get your well water tested?

| | |
|---|---|
| 2–3 times a year | ☐ |
| Once a year | ☐ |
| Once every few years | ☐ |
| I have had my well tested once | ☐ |

19. For which contaminant types have you had your well water tested?

| | |
|---|---|
| Bacteriological | ☐ |
| Chemical | ☐ |
| Both | ☐ |
| Don't remember | ☐ |

20. For which of the following reasons did you have your well water tested? (tick all that apply)

| | | | |
|---|---|---|---|
| To determine well water quality | ☐ | Period of heavy rainfall | ☐ |
| Change in water smell/taste/clarity | ☐ | Period of heavy snowfall | ☐ |
| Family member/friend became ill | ☐ | As part of regular maintenance | ☐ |
| Nearby construction activity | ☐ | Peace of mind | ☐ |
| Occurrence of drought | ☐ | Offered free test | ☐ |
| Occurrence of flood | ☐ | Other | ☐ |

21. For which of the following reasons would you test your well water in the future? (tick all that apply)

| | | | |
|---|---|---|---|
| To determine well water quality | ☐ | Period of heavy rainfall | ☐ |
| Change in water smell/taste/clearness | ☐ | Period of heavy snowfall | ☐ |
| If a family member/friend becomes ill | ☐ | As part of regular maintenance | ☐ |
| If there is nearby construction activity | ☐ | Peace of mind | ☐ |
| Occurrence of drought | ☐ | If it's free | ☐ |
| Occurrence of flood | ☐ | Other | ☐ |

22. Has anyone in your household suffered from a gastrointestinal illness (symptoms may include: vomiting, diarrhea, abdominal cramps, or fever) in the past 12 months?

| | |
|---|---|
| Yes | ☐ |
| No | ☐ |
| Don't know | ☐ |

23. Gastrointestinal illnesses are caused by bacteriological contaminants known as "pathogens." To the best of your knowledge, which of these pathogens can be found in private wells?

| **Scored variable: Knowledge of pathogens found in well water** | | | | |
|---|---|---|---|---|
| | **Yes** | **No** | **Don't know** | |
| Campylobacter | ☐ | ☐ | ☐ | **Score** |
| Cryptosporidium | ☐ | ☐ | ☐ | Aware of 4–6: 2 |
| Giardia | ☐ | ☐ | ☐ | Aware of 1–3: 1 |
| Norovirus | ☐ | ☐ | ☐ | Aware of 0: 0 |
| Salmonella | ☐ | ☐ | ☐ | |
| Verotoxigenic E. coli | ☐ | ☐ | ☐ | |

24. Which sources, if any, do you associate with pathogenic contaminants?

| **Scored variable: Knowledge of pathogen sources** | | | | |
|---|---|---|---|---|
| | **Yes** | **No** | **Don't know** | |
| Septic tanks | ☐ | ☐ | ☐ | **Score** |
| Farmyards | ☐ | ☐ | ☐ | Aware of 3–4: 2 |
| Grazing animals | ☐ | ☐ | ☐ | Aware of 1–2: 1 |
| Domestic animals | ☐ | ☐ | ☐ | Aware of 0: 0 |

**Section 3: Post-EWE actions and risk perception**

25. In your opinion, what is the likelihood of the following events affecting your well water?

| **Scored variable: Likelihood of extreme weather events** | **Likely** | **Neither likely nor unlikely** | **Unlikely** | **Don't know** |
|---|---|---|---|---|
| Drought | ☐ | ☐ | ☐ | ☐ |
| Flood | ☐ | ☐ | ☐ | ☐ |
| Heavy rainfall | ☐ | ☐ | ☐ | ☐ |
| Snowfall | ☐ | ☐ | ☐ | ☐ |
| **Score** | 2 | 1 | 0 | |

26. What impact do you believe the following events would have on your well water quality?

| **Scored variable: Severity of extreme weather events** | **Serious** | **Moderate** | **Minor** | **Don't know** |
|---|---|---|---|---|
| Drought | ☐ | ☐ | ☐ | ☐ |
| Flood | ☐ | ☐ | ☐ | ☐ |
| Heavy rainfall | ☐ | ☐ | ☐ | ☐ |
| Snowfall | ☐ | ☐ | ☐ | ☐ |
| **Score** | 2 | 1 | 0 | |

27. Which, if any, of these recent weather events directly affected you and your residence? (tick all that apply)

| | |
|---|---|
| Storm Deirdre (December 2018 rainfall, floods) | ☐ |
| Summer drought 2018 | ☐ |
| "Beast from the East" (March 2018 snowstorm) | ☐ |
| Storm Ophelia (October 2017 rainfall, floods) | ☐ |
| Winter 2013/14 floods | ☐ |
| None of the above | ☐ |

Respondents selecting "None of the above" instructed to skip Questions 28–29.
Respondents selecting at least one weather event instructed to skip Question 30.

28. Did you notice any of the following changes during or after the selected weather event(s)?

| | Yes | No | Don't know |
|---|---|---|---|
| Occurrence of gastrointestinal illness | ☐ | ☐ | ☐ |
| Quantity of water | ☐ | ☐ | ☐ |
| Water taste | ☐ | ☐ | ☐ |
| Water color | ☐ | ☐ | ☐ |
| Water odor | ☐ | ☐ | ☐ |

29. Which of the following actions did you or your household take during the selected weather event(s)? (tick all that apply)

| | | | |
|---|---|---|---|
| Boiled water | ☐ | Tested well water | ☐ |
| Carried out visual well inspection | ☐ | Treated well water | ☐ |
| Enquired about well maintenance/safety | ☐ | Other | ☐ |
| Switched to bottle water/other domestic source | ☐ | Did not take any action | ☐ |

30. Which of the following actions would you take during future weather event(s)? (tick all that apply)

| | | | |
|---|---|---|---|
| Boil water | ☐ | Test well water | ☐ |
| Carry out visual well inspection | ☐ | Treat well water | ☐ |
| Enquire about well maintenance/safety | ☐ | Other | ☐ |
| Switch to bottle water/other domestic source | ☐ | Would not take any action | ☐ |

31. To what extent would you agree with the following statements?

| **Scored variable: Impact of extreme weather events** | **Agree** | **Neither agree nor disagree** | **Disagree** | **Don't know** |
|---|---|---|---|---|
| A properly constructed well will withstand impacts of drought and heavy rainfall * | ☐ | ☐ | ☐ | ☐ |
| Well water may remain contaminated after flood, drought, or snowmelt | ☐ | ☐ | ☐ | ☐ |
| Warmer temperatures may affect survival of pathogens in well water | ☐ | ☐ | ☐ | ☐ |
| Occurrence of drought may lead to increased contaminant levels in well water | ☐ | ☐ | ☐ | ☐ |
| Increased rainfall may impact transport of contaminants to well water | ☐ | ☐ | ☐ | ☐ |
| **Score** | 2 | 1 | 0 | |

* Scores in reverse order.

32. Which of the following would you consider most important when installing a well? (please select your top three choices)

| | | | |
|---|---|---|---|
| Water quality | ☐ | Local climate | ☐ |
| Water quantity | ☐ | Local flood history | ☐ |
| Well type | ☐ | Location of wastewater treatment system | ☐ |
| Construction/maintenance costs | ☐ | Nearby land use | ☐ |

33. How concerned are you about the following in terms of groundwater contamination?

| | Concerned | Neither concerned nor unconcerned | Unconcerned |
|---|---|---|---|
| Human contamination | ☐ | ☐ | ☐ |
| Climate change impacts | ☐ | ☐ | ☐ |
| Presence of pathogens | ☐ | ☐ | ☐ |
| Agricultural runoff | | | |
| Chemical/pesticide use | | | |
| Industrial activity | | | |

**Section 4: Information seeking behavior and confidence in maintaining supply**

34. Who do you believe should be responsible for protecting the groundwater where you live? (please select your top three choices)

| | | | |
|---|---|---|---|
| Environmental Protection Agency | ☐ | Local authorities | ☐ |
| Geological Survey of Ireland | ☐ | Industry (e.g., agriculture, mining) | ☐ |
| Health Service Executive | ☐ | My community | ☐ |
| Irish Water | ☐ | Myself | ☐ |

35. How confident are you in your ability to look after your well?

| | |
|---|---|
| Not confident | ☐ |
| Somewhat confident | ☐ |
| Very confident | ☐ |
| Don't know | ☐ |

36. Which of the following pose a barrier to maintaining your well? (tick all that apply)

| | | | |
|---|---|---|---|
| Lack of information | ☐ | Financial cost | ☐ |
| Lack of clear guidance | ☐ | Difficulties in collecting water samples | ☐ |
| Lack of knowledge | ☐ | Distance from laboratory | ☐ |
| Lack of time | ☐ | Other | ☐ |

37. Have you or your household sought information about well maintenance/safety in the past?

| | |
|---|---|
| Yes | ☐ |
| No | ☐ |
| Don't know | |

Respondents selecting "No" or "Don't know" instructed to skip Question 38.
Respondents selecting "Yes" instructed to skip Question 39.

38. Which of the following sources did you consult? (tick all that apply)

| | | | |
|---|---|---|---|
| Local authority | ☐ | Building contractor | ☐ |
| Environmental Protection Agency | ☐ | Well driller | ☐ |
| Geological Survey of Ireland | ☐ | Friend | ☐ |
| Health Service Executive | ☐ | Relative | ☐ |
| Irish Water | ☐ | Other | ☐ |

39. Which of the following sources would you consult if you have a query about well maintenance/safety? (tick all that apply)

| | | | |
|---|---|---|---|
| Local authority | ☐ | Building contractor | ☐ |
| Environmental Protection Agency | ☐ | Well driller | ☐ |
| Geological Survey of Ireland | ☐ | Friend | ☐ |
| Health Service Executive | ☐ | Relative | ☐ |
| Irish Water | ☐ | Other | ☐ |

40. How would you like to receive information about well maintenance? (tick all that apply)

| | | | |
|---|---|---|---|
| Brochure/leaflet | ☐ | Text message | ☐ |
| Public meeting | ☐ | Informative video | ☐ |
| Information pack | ☐ | Website | ☐ |
| Newspaper article | ☐ | Workshop | ☐ |
| Radio segment | ☐ | Other | ☐ |

41. If given the opportunity, would you prefer to be connected to a public drinking water supply?

| | |
|---|---|
| Yes | ☐ |
| No | ☐ |
| Don't know | ☐ |