Iechyd Cyhoeddus Cymru
Public Health Wales

Gwasanaeth Tystiolaeth
Evidence Service
Adroddiad cwmpasu ystwyth
Agile scoping report

Private water supplies: An agile scope of the literature

Compiled by:

Anamica Patel, Advanced Evidence and Knowledge Analyst, Public Health Wales
Golibe Ezenwugo, Evidence and Knowledge Analyst, Public Health Wales

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Introduction

This agile report outlines the findings of a search conducted by the Evidence Service to identify evidence about the potential health impacts of using private water supplies (PWS). It covers several questions that emerged as we explored the evidence landscape and discussed the topic with the stakeholders. Initially, we sought to find systematic reviews containing primary studies from Wales, UK or other European/Australian/North American countries, relating to health impacts of PWS use, including those relating to microbial and chemical effects, and potential impacts resulting from a changing climate, such as flooding. In the absence of systematic reviews, primary studies were directly sought. We also looked for primary studies exploring views, perceptions, or experiences of users of PWS regarding the potential health risks associated with the use of PWS as well as regarding the impact of climate change on the quality of PWS.

This work will help the stakeholders to understand what is known about the health risks and impacts of using PWS. It will support the development of recommendations on what further work is needed to increase our understanding of these and, where identified, recommendations on actions to protect public health in Wales.

The findings and conclusions included are those of the source authors and not an interpretation by the Evidence Service. Information relevant to answering the questions identified from the included primary studies have been extracted and briefly summarised within this report. If specific information is of interest, it is advisable to read the sources from where they were taken in more detail. If utilising any studies included in this scope to inform policy, it is important to consider the generalisability of their findings to your context.

The search undertaken for this scope is unlikely to have identified all evidence relating to this topic, as searches were not exhaustive, but instead focussed on identifying robust systematic reviews and later primary studies from limited number of sources.

Objectives

To conduct a scoping review to identify published evidence addressing the following question:

1a. What are the potential health risks/impacts of using PWS?

1b. What are the views, perceptions and/ or experiences of users of PWS regarding the potential health risks associated with the use of PWS?

2a. What likely impacts changing climate may have on PWS including the potential health risks to the users?

2b. What are the views, perceptions and/ or experiences of users of PWS regarding the impact of climate change on PWS and the risks associated with their use?

Key Messages

- No robust secondary evidence was identified relevant to the potential health risks or impacts of using PWS However, published systematic reviews focussing on other aspects of PWS within the UK do exist.
- In the absence of secondary evidence, a search for primary literature was undertaken. Fifteen relevant primary studies were identified. Many focussed on understanding the microbiological and chemical quality of PWS and quantifying the breach of the statutory limits rather than exploring the direct health impact of PWS.
- Environmental investigations of two documented gastroenteritis outbreaks identified consumption of water from PWS as the most likely transmission route. However, a dose-response effect calculation of illness and consumption of water could not be performed due to a lack of available data. Therefore, the link between PWS and outbreaks is unclear.
- Evidence suggests low level compliance of water quality standards for PWS. However, the statutory limits for contaminants are not always based on toxicological grounds, and therefore breaches of these standards might not necessarily imply a risk to health for some contaminants.
- Comparison between public and PWS was rarely conducted. However, where it was, failure rate of PWS for at least one chemical parameter was higher than public supplies.
- Findings point to the need for regulators to reinforce the guidance on meeting drinking water quality standards to PWS providers and users, and the benefits to long-term health of complying with these.
- The small number of observational studies monitoring seasonal trends and analysis of PWS quality indicated short-term episodic peaks of faecal indicator and pathogen concentration following periods of heavy rainfall.
- While some statistical relationship was found between faecal indicator organisms and the presence of pathogens, their use in assessments of regulatory compliance may not always provide a robust measure of public health risk. As the indicator absence i.e., sample meeting regulatory compliance levels, does not prevent pathogen presence and therefore can still bear risk to public health.
- No UK or Ireland studies exploring the views and perceptions of PWS users were identified.
- Perceptions of PWS users from non-UK studies were generally positive regarding water quality despite concerns about water contamination regarding safety.
- Only key terms for PWS and its health impacts were used to search the literature for this agile report. Therefore, it is likely that relevant research on the topic has been missed.

Findings

The searches did not identify any robust systematic reviews or well-conducted UK and Ireland primary studies directly addressing these questions, thereby identifying a need for further research on this topic.

Fifteen epidemiological studies of relevance to the scope of this report were identified, comprising of three cross-sectional studies, three time series analyses, four secondary analyses, three cohort studies and two focus group analyses. These predominantly focused on:

1) reviewing outbreak data to determine association of waterborne spread of intestinal infections to untreated or poorly treated PWS
2) determining the chemical quality (e.g., nitrate, aluminium, arsenic) of PWS and quantifying the breach of the statutory limits due to contamination
3) determining causes of contamination by monitoring seasonal trends and/or epidemiological risk factors like proximity to livestock
4) exploring views and perceptions regarding the safety and quality of PWS
5) identifying barriers to testing PWS.

Data from the studies including study design, location, methodology, results, limitations, and generalisability of the findings, are presented in Table 2.

1a. What are the potential health risks/impacts of using private water supplies (PWS)?

Eleven studies investigating the microbiological and chemical quality of PWS were identified. Of these, two studies conducted in England investigated epidemiology and sources of outbreaks of intestinal infections due to Cryptosporidium and Campylobacter. Based on the environmental investigations of the outbreak settings and their surrounding areas, consumption of water from PWS was identified as a likely transmission route (Duke et al. 1996 and Hoek et al. 2008). The current studies did not find a direct relationship between PWS and the outbreaks. Their conclusion of PWS as a potential source of transmission were based on descriptive epidemiology and environmental observations rather than evidence from testing water samples.

A study by Risebro et al. (2012) found elevated risk of infectious intestinal disease in consumers of PWSs contaminated with Enterococci compared to those drinking from PWSs complying with current standards across two rural areas of England: East Anglia and Herefordshire. Though it did not identify an overall association between the disease risk and presence of indicator bacteria, subgroup analyses by age, revealed that for children under ten, the relative risk of disease in those drinking from contaminated supplies was higher for both incidence [4.8 (95%CI: 1.5, 15.3)] and prevalence [8.9 (95%CI: 2.8, 27.5)]. The different relative risk estimates for incidence and prevalence rates would indicate longer duration of illness per episode in children, however this did not achieve significance and the authors were unable to undertake further analyses on the impact of duration of illness on the study findings due to small sample size.

Four studies analysing microbiological quality of PWS reported considerable contamination. One study reported incidence rate of *E. coli* contamination in groundwater derived PWS in Ireland for samples analysed between 2011-2012, to be 58.4% (O'Dwyer et al. 2014). Similarly, analyses of drinking water samples from seven commercial PWS (establishments using a PWS for commercial uses; six PWS were treated) across UK (two in Wales) and Ireland, for the protozoan parasites Cryptosporidium and Giardia identified positive concentrations for these organisms in all the sampled supplies and frequent failures of faecal indicator standards (Kay et al. 2007). Furthermore, two studies from Scotland and England analysing quality of PWS from commercial and non-commercial properties for presence of coliforms (total and faecal), nitrate or *E. coli*, identified high sample failure of drinking water standards for these microbes (Reid et al. 2003 and Rutter et al. 2000). Approximately 50% samples in the former study by Reid et al. (2003) and 21% samples from 33% PWS in the latter study by Rutter et al. (2000) failed the regulations for coliform and/or nitrate, and *E. coli*.

Two studies analysed the overall chemical quality of drinking water from PWS and found low level compliance with water quality standards (Ander et al. 2016 and Harrison et al. 2000). The study by Ander et al. (2016) sampled drinking water from 497 properties using PWS across Cornwall and analysed it for 25 chemical parameters whereas the study by Harrison et al. (2000) collated data for samples from 1297 PWS across the West Midland Region. The parameters that most frequently fell outside the Prescribed Concentration Value (PCV) in both studies were pH, metals (including arsenic, aluminium, manganese and iron), and Nitrates. When interpreting these results, it is important to note that since not all statutory limits for contaminants are based on toxicological grounds, and statutory limits have changed over time, breaches of these standards do not necessarily imply a risk to health[1].

To explore the potential health risks, a follow-up biomonitoring study in a subset of the sample of Ander et al. (2016), identified positive correlation between drinking water arsenic concentrations and toenail and hair arsenic concentrations, thereby indicating prolonged exposure and a potential health concern (Middleton et al. 2016). Even though this cohort study used repeat monitoring of drinking water and biological matrices like toenails and hair to assess the longevity and temporal variation of arsenic concentrations in PWS, authors identified that a large degree of variation in toenail and hair biomarkers was unaccounted for in this study. With exposure to soil and dust highly possible explanations in a region of well-

[1] DEFRA. *The Private Water Supplies Regulations 2009.* (Vol. Water, England. Statutory Instrument No. 3101), 2009.
WHO, *Arsenic in drinking-water – Background document for development of WHO Guidelines for Drinking-water Quality*, World Health Organisation, WHO/SDE/WSH/03.04/75/Rev/1, 2011.
WHO. *Guidelines for drinking-water quality (4th ed.)*. Geneva: World Health Organization, 2011.

documented elevated environmental arsenic, further investigation into the significance of other exposure routes is warranted as the focus of future research.

A quantitative microbial risk assessment of the risk of Giardia and Cryptosporidium in very small PWSs by Hunter et al. (2011) utilised existing data from the study by Kay et al. (2007) and national surveillance data of *E. coli* in PWSs in England and France, to estimate the potential annual risks of infection with the pathogens. The analyses indicate a major risk of Cryptosporidium and Giardia infection in people consuming unboiled tap water from very small PWSs. The model estimated very high risk of infection with the median annual risk being of the order of 25 in England and 28% in France for Cryptosporidium and 0.4% for England and 0.5% for France for Giardia. It is worth noting that the model did not include the effects of seasonality in the risk calculations. Additionally, data from Kay et al. (2007) on Cryptosporidium and Giardia from large commercial PWSs was used to derive regression equations describing the relationships between the concentration of these pathogens and *E. coli* in PWSs. Thereby, authors assumed that the relationship between *E. coli* and pathogen counts in the small systems was similar to those found in the large commercial PWSs.

Regular PWS sampling appears necessary as studies indicated failed post-test treatment analysis among households treated for bacteriological safety and/or specific metal removal (Duke et al. 1996, Harrison et al. 2000, Rutter et al. 2000, Kay et al. 2007 and Ander et al. 2016).

1b. What are the views, perceptions and/ or experiences of users of PWS regarding the potential health risks associated with the use of PWS?

Three methodologically limited studies were identified (two qualitative and one cross-sectional) that addressed this question. Participant views regarding the quality of their PWS were generally positive, despite the concern about water contamination from nearby agricultural activities (VanDerGeest et al. 2020 and Jones et al. 2005). Both qualitative studies were conducted in rural settings, with considerable demographic and cultural differences amongst the study participants; rural agricultural Latino communities comprising of a mix of Spanish- and English-speakers in USA compared to all White English-speaking participants served by PWS in the City of Hamilton in Canada. Therefore, applicability and generalisability of these studies to Welsh context needs further consideration.

The studies also explored barriers to testing PWS and identified inconvenience of the testing process, acceptable test results in the past, resident complacency and lack of knowledge, actionable information, and technical support as key barriers. Both studies described concerns about bacterial and chemical contamination from agricultural sources, illegal dumping of pollutants and the lack of an official monitoring system for drinking water from PWS. Only participants in one study (VanDerGeest et al., 2020) identified home repair experience as factor that may support PWS supervision through helping build self-efficacy.

Additionally, a cross-sectional study collected the views towards the risk associated with *E. coli* O157 using two case study areas of Grampian (Scotland), and North Wales to offer a rural-urban contrast in *E. coli* O157 disease incidence (Stratchan et al. 2011). High levels of self-reported knowledge (awareness) of *E. coli* tended to be reported more by people living in medium to high disease incidence areas; however, the study did not find an association between perceived likelihood of personal lifetime illness from *E. coli* and relative levels of disease incidence. Hence identifying a disconnect between knowledge and perceived risk i.e., individuals may be aware of the factors determining exposure, but may still over- or under- estimate their own personal likelihood of exposure through other psychological factors (e.g., level of dread, control, familiarity, etc.).

As noted in table 2, several flaws were identified during critical appraisal of these studies. The studies utilised both self-report and objective measures to collect data. However, the validity of some tools was unclear and therefore there is risk of self-reporting bias. Recruitment was voluntary, sample size was not calculated in the cross-sectional study and data saturation was not achieved in the qualitative studies. Therefore, representativeness of the sample is not guaranteed in addition to risk of self-selection and non-response biases. Additionally, there was lack of consideration of reflexivity or discussion of power relationships was noted in the qualitative studies. They offered incentive to participants, but there was no exploration of any potential implications. In these contexts, the lack of any discussion of their reflexive process by the researchers is particularly problematic. All of these factors need to be considered when inferring findings presented in this section.

A valid understanding of perceptions needs and concerns of users of PWS is integral to the development of effective public health strategic planning, public education programs and drinking water policy. There is a lack of directly relevant research in relation to the perceptions of drinking water from PWS users in Wales.

2a. What are the likely impacts that a changing environment and climate may have on PWS and health impacts to users?

Our searches failed to identify any good quality primary studies that directly analysed the impact of climate change on PWS. However, five epidemiological studies (Kay et al. 2007, O'Dwyer et al. 2014, Reid et al. 2003 and Rutter et al. 2000) from UK and/or Ireland, were identified that examined seasonal trends and extreme weather events to understand patterns of microbiological contamination of non-commercial and/or commercial PWS.

A study utilised a logistic regression model to assess the impact of rainfall and aquifer characteristics to predict the probability of contamination of groundwater PWS with *E. coli* in Ireland (O'Dwyer et al. 2014). The model indicated that the likelihood of *E. coli* contamination was greater with increased rainfall and in areas where a bedrock aquifer is dominant. It also found aquifer material played a dominant role in vulnerability to microbial contamination. Authors noted the limitations of their model and used it as a tool to highlight areas where faecal contamination is more likely, thus an indication that a groundwater system is being polluted and requires remediation.

Findings from Cryptosporidium and Giardia analyses of daily samples (n= 1178) of drinking water over two six-week periods in the spring and autumn of 2000 across seven commercial PWS across UK and Ireland, indicated short-term episodic peaks of faecal indicator and pathogen concentration following periods of heavy rainfall (Kay et al. 2007). This study indicates that surface water supplies were more variable in quality and likely to be more susceptible to impacts of rainfall. It is however important to note that six supplies were treated and though some statistical relationship was found between faecal indicator organisms and the presence of these pathogens, their use in assessments of regulatory compliance did not appear to provide a robust measure of public health risk, i.e., indicator absence does not preclude presence of these protozoan pathogens.

Moreover, parasite positive samples were observed at some sites only during phase 2 of the study (i.e., the autumn) that could be attributed to the seasonal patterns of livestock management. As the bacterial indicator and protozoan parasite response to rainfall was often variable in magnitude for a particular level of rainfall, the causes of such variation need further investigation.

Two studies analysing quality of PWS from both commercial and non-commercial properties identified seasonal trends in the presence of coliforms (total and faecal), nitrate or *E. coli* (Reid et al. 2003 and Rutter et al. 2000). Failure rates on microbiological grounds displayed a seasonal trend being greater during the latter half of the year whereas concentrations of nitrate tended to display an opposite trend with a greater number of failures occurring during the spring period and no relationship with rainfall was immediately apparent (Reid et al. 2003). The rates of failure for coliforms or nitrate were comparable, suggestive of direct contamination of the groundwater source in most cases rather than a storage or supply line contamination mechanism. It is notable that authors obtained historic data for microbiological drinking water quality and conducted a simple comparison between seasonal average rainfall amount and failure rate that showed a significant (although low) positive relationship for coliforms.

Similarly, seasonal variation in PWS water quality was examined in the study by Rutter et al. (2000) and analysis revealed the percentage of samples positive for *E. coli* to be highest in summer and autumn, and lowest in winter. As this was a secondary analysis, authors note that the study was limited by the difficulty of collecting background information such as the class, source and treatment of many supplies from local authorities due to concern by local authorities about confidentiality.

Furthermore, an investigation to identify possible association between the cumulative incidence of sporadic cases of *Cryptosporidium parvum* and

Cryptosporidium. hominis in Scotland, and explanatory spatial and temporal variables (including PWS data) from 2005 to 2007, demonstrated differences between the two *Cryptosporidium* species in the time of year, at which the peak number of cases occurred (Pollock et al. 2010). The increase was observed in the same months each year over the 2 years period: *C. parvum* cases peaked in March to June, and *C. hominis* in August to November; and PWS were identified as an important variable with reports significantly more likely to be due to the zoonotic species *C. parvum*.

As identified by the authors, several factors should be considered when interpretating these results including the unaccountability of the edge effects[2] as well as the role of livestock. Furthermore, the spatial models used in Pollock et al. (2010) considered only straight-line distances. This might have significant effects in coastal or mountainous regions where geographical features might create biological boundaries.

Overall, the studies in this section suggested identification of periods of greatest contamination risk and using targeted sampling of PWS to make the most efficient use of the limited resources available for monitoring PWS.

2b. What are the views, perceptions and/ or experiences of users of PWS regarding the impact of climate change on PWS and the risks associated with the use of PWS?

Our searches failed to identify any good quality primary studies that directly addressed this question.

Additional studies of potential interest

Our search identified a substantial body of research predominantly in the form of narrative reviews or primary studies that did not meet our inclusion criteria and were excluded following discussions with the stakeholders. However, the following references might be of interest to the stakeholders. If these were used for policy and practice initiatives, assessment of their quality would be necessary.

- Bacci F and Chapman DV (2011) Microbiological assessment of private drinking water supplies in Co. Cork, Ireland. Journal of water and health 9(4): 738-751. Available here.
- Brown L, Medlock J and Murray V (2014) Impact of drought on vector-borne diseases--how does one manage the risk? Public health 128(1): 29-37. Available here.
- Crabbe H, Fletcher T, Close R, et al. (2017) Hazard Ranking Method for Populations Exposed to Arsenic in Private Water Supplies: Relation to Bedrock

[2] "Edge effect occurs when the study area is defined by a border which does not actually prevent travel across the border" Fortney et al. 2000. More precisely, it manifests when the boundaries of the study area affect a given spatial measurement and lead to the distortion of estimates. Fortney J et al. 2000. Comparing alternative methods of measuring geographic access to health services. Health Services and Outcomes Research Methodology. 1:173-84.

Geology. International journal of environmental research and public health 14(12). Available here.
- Delpla I, Jung AV, Baures E, et al. (2009) Impacts of climate change on surface water quality in relation to drinking water production. Environment international 35(8): 1225-1233. Available here.
- Furtado C, Adak GK, Stuart JM, et al. (1998) Outbreaks of waterborne infectious intestinal disease in England and Wales, 1992-5. Epidemiology and infection 121(1): 109-119. Available here.
- Garvey P, Carroll A, McNamara E, et al. (2016) Verotoxigenic Escherichia coli transmission in Ireland: a review of notified outbreaks, 2004-2012. Epidemiology and infection 144(5): 917-926. Available here.
- Homoncik SC, Macdonald AM, Heal KV, et al. (2010) Manganese concentrations in Scottish groundwater. The Science of the total environment 408(12): 2467-2473. Available here.
- Hunter PR (2003) Climate change and waterborne and vector-borne disease. Journal of applied microbiology 94: 37S-46S. Available here.
- Jarvie HP, Neal C, Smart R, et al. (2001) Use of continuous water quality records for hydrograph separation and to assess short-term variability and extremes in acidity and dissolved carbon dioxide for the River Dee, Scotland. The Science of the total environment 265(1): 85-98. Available here.
- Mooney S, Boudou M, O'Dwyer J, et al. (2022) Behavioral pathways to private well risk mitigation: A structural equation modeling approach. Risk analysis : an official publication of the Society for Risk Analysis. Available here.
- Nichols G, Lane C, Asgari N, et al. (2009) Rainfall and outbreaks of drinking water related disease and in England and Wales. Journal of water and health 7(1): 1-8. Available here.
- Richardson HY, Nichols G, Lane C, et al. (2009) Microbiological surveillance of private water supplies in England: the impact of environmental and climate factors on water quality. Water research 43(8): 2159-2168. Available here.
- Said B, Wright F, Nichols GL, et al. (2003) Outbreaks of infectious disease associated with private drinking water supplies in England and Wales 1970-2000. Epidemiology and infection 130(3): 469-479. Available here.

Considerations

- Although a comprehensive search was undertaken to identify robust systematic reviews, followed by searches for primary studies, the search was not exhaustive. Therefore, it is possible that searches of additional databases (including the grey literature) may have identified systematic reviews and further primary studies addressing the research questions.
- It is important to note that some included studies may have used contemporaneous but now outdated water quality standards.

- Questions 1b and 2b were included at the request of stakeholders following title and abstract screening. Therefore, it is possible some relevant studies have been missed. Despite this limitation, it was agreed not to re-run the searches due to time constraints. Following discussions with the stakeholders, non-UK studies were included for Q1b and Q2b, however we would recommend evaluating their generalisability to Wales context.

Options for further work

It is highly likely that our searches did not identify all the evidence (secondary and primary) relevant to this topic, as our search strategy only included key terms for PWS, and many relevant studies may not always refer to the term itself. However, based on the scarcity of published primary studies identified in this report, there is limited scope for further work by the Evidence Service on this topic.

Methods

Appendix A (technical appendix) provides an outline of the general rationale and methods used to develop agile scopes. The following methodology outlines the approach undertaken for this agile scoping report.

As this is a broad topic, this agile scope was initially limited to only include reviews produced using explicit and reproducible methods of systematic searching, critical appraisal of quality and synthesis of the primary literature on the topic. This is an acceptable way to rapidly assess the majority of the evidence base, and although it does not intend to identify every publication on a topic, it would allow for the production of an overview. However, the initial search did not identify any systematic reviews addressing the topic and following discussions with the stakeholders, primary studies were searched.

Data sources: Twenty reliable evidence sources were searched that adhere to robust systematic review principles[3], Google scholar, Epistemonikos and Medline were searched for published systematic review evidence using search terms and strategies designed specifically for each data source. Google scholar and Medline were searched for published primary studies using a combination of the following terms as described in Appendix B:

- Private water supply/ies
- Private well supply/ies
- Borehole
- Well water
- Groundwater
- Climate change
- Rainfall
- Storm
- Drought
- Health risk/ impact
- Views/ perceptions/ beliefs
- Barriers/ factors

A full list of resources searched is included in appendix B (search appendix). Additionally, topic experts were consulted to identify relevant studies.

Study selection: Primary studies were assessed for inclusion. Two reviewers independently screened the reviews for relevance at title, abstract and full-text level against the inclusion criteria outlined in table 1.

[3] Follows core systematic review principles: comprehensive and stated search strategy, selection of sources based on objective criteria, assessment of risk of bias of primary sources and/or is a methodology developed by an expert body e.g. NICE. For a full list of sources searched, please refer to Sources searched section of the report.

Data extraction: Where possible, data reporting relevant characteristics were extracted from the included reviews into data extraction tables (table 2). A second reviewer checked the extracted data. Disagreements at any stage were resolved through discussion with a third reviewer.

Quality assessment: The included primary studies were critically appraised for their quality. One reviewer critically appraised all the included studies using study design appropriate checklist by the Specialist Unit for Review Evidence (SURE). A second reviewer undertook a consistency check for approximately 20% of included papers which were discussed to establish inter-rater reliability. Any concerns about the methodological quality of the studies were noted under 'reviewer comments' in the data extraction table. Only studies considered to be of good enough quality were included in this agile scope.

Table 1a. Inclusion/ Exclusion criteria for Q1a.

What are the potential health risks/impacts of using PWS?

	Include	Exclude
Population	Adults and children who use/are exposed to private water supplies	
Exposure	Private water supply	
Outcomes	Health risks/ impacts	Any other outcomes
Study design	Published primary literature of any design	Reviews (any type), Grey literature
Research type	Any research design: quantitative or mixed methods with relevant quantitative data	
Country	UK, Ireland	All other countries
Other study considerations: English language only		

Table 1b. Inclusion/ Exclusion criteria for Q1b.

What are the views, perceptions and/ or experiences of users of PWS regarding the potential health risks associated with the use of PWS?

	Include	Exclude
Sample	Adults and children who use/are exposed to private water supplies	
Phenomenon of interest	Health risks associated with usage of private water supply	
Design	Published primary literature of any design	Reviews (any type), Grey literature
Evaluation	Views, perceptions, experiences	Any other outcomes
Research type	Qualitative/ or mixed methods with relevant data	
Country	UK, Ireland, USA and Canada	All other countries
Other study considerations: English language only		

Table 2a. Inclusion/ Exclusion criteria for Q2a.

What likely impacts changing climate may have on PWS including the potential health risks to the users?

Population	Adults and children who use/are exposed to private water supplies	
Exposure	Climate change	
Outcomes	Quality of Private water supply and Health risks/ impacts to its users	
Study design	Primary studies	Reviews (any type), policy documents
Research type	Any research design: quantitative or mixed methods with relevant quantitative data	
Country	UK, Ireland	All other countries
Other study considerations: English language only		

Table 2b. Inclusion/ Exclusion criteria for Q2b.

What are the views, perceptions and/ or experiences of users of PWS regarding the impact of climate change on PWS and the risks associated with their use?

	Include	Exclude
Sample	Adults and children who use/are exposed to private water supplies	
Phenomenon of interest	Climate change and its impact on quality of PWS Health risks / impacts to its users	
Design	Published primary literature of any design	Reviews (any type), Grey literature
Evaluation	Views, perceptions, experiences	Any other outcomes
Research type	Qualitative/ or mixed methods with relevant data	
Country	UK, Ireland, USA and Canada	All other countries
Other study considerations: English language only		

References

Ander EL, Watts MJ, Smedley PL, et al. (2016) Variability in the chemistry of private drinking water supplies and the impact of domestic treatment systems on water quality. Environmental geochemistry and health 38(6): 1313-1332.

Duke LA, Breathnach AS, Jenkins DR, et al. (1996) A mixed outbreak of cryptosporidium and campylobacter infection associated with a private water supply. Epidemiology & Infection 116(3): 303-308.

Harrison WN, Bradberry SM and Vale JA (2000) Chemical contamination of private drinking water supplies in the West Midlands, United Kingdom. Journal of toxicology. Clinical toxicology 38(2): 137-144.

Hoek MR, Oliver I, Barlow M, et al. (2008) Outbreak of Cryptosporidium parvum among children after a school excursion to an adventure farm, south west England. Journal of water and health 6(3): 333-338.

Hunter PR, De Sylor MA, Risebro HL et al. (2011) Quantitative microbial risk assessment of cryptosporidiosis and giardiasis from very small private water supplies. Risk Analysis: An International Journal. 31(2): 228-36.

Jones AQ, Dewey CE, Dore K, et al. (2005) Public perception of drinking water from private water supplies: focus group analyses. BMC public health 5: 129.

Kay D, Watkins J, Francis CA, et al. (2007) The microbiological quality of seven large commercial private water supplies in the United Kingdom. Journal of water and health 5(4): 523-538.

Middleton DRS, Watts MJ, Hamilton EM, et al. (2016) Prolonged exposure to arsenic in UK private water supplies: toenail, hair and drinking water concentrations. Environmental science. Processes & impacts 18(5): 562-574.

O'Dwyer J, Dowling A and Adley CC (2014) Microbiological assessment of private groundwater-derived potable water supplies in the Mid-West Region of Ireland. Journal of water and health 12(2): 310-317.

Pollock KGJ, Ternent HE, Mellor DJ, et al. (2010) Spatial and temporal epidemiology of sporadic human cryptosporidiosis in Scotland. Zoonoses and public health 57(7): 487-492.

Reid DC, Edwards AC, Cooper D, et al. (2003) The quality of drinking water from private water supplies in Aberdeenshire, UK. Water research 37(2): 245-254.

Risebro HL, Breton L, Aird H, (2012) Contaminated small drinking water supplies and risk of infectious intestinal disease: A prospective cohort study. e42762.

Rutter M, Nichols GL, Swan A, et al. (2000) A survey of the microbiological quality of private water supplies in England. Epidemiology and infection 124(3): 417-425.

Strachan NJC, Hunter CJ, Jones CDR, et al. (2011) The relationship between lay and technical views of Escherichia coli O157 risk. Philosophical transactions of the Royal Society of London. Series B, Biological sciences 366(1573): 1999-2009.

VanDerGeest K, Ko LK, Karr C, et al. (2020) Private well stewardship within a rural, agricultural Latino community: a qualitative study. BMC public health 20(1): 863.

Appendix A: Technical document

AGILE SCOPES are stakeholder-driven, rapid, systematic overviews of the evidence on a topic. They provide a transparent and reliable overview of the evidence landscape and are useful to:

- establish what literature exists
- help to refine a broad question
- identify gaps in the evidence
- inform further work by stakeholders.

The scopes employ a process of *up to* three steps, depending on what evidence is available for the topic. Progress from one step to another is discussed and agreed with stakeholders.

1. The first step is to draw on existing systematic review evidence identified from trusted sources[4] (secondary evidence sources that use robust methodologies) where this exists. The Evidence Service does not undertake critical appraisal of these reviews. A brief report outlining evidence identified is produced.
2. If little or no evidence has been identified at this stage, a very simple search will be conducted in Medline using key words only to establish the benefit of conducting further searches in a broader range of databases. A summary of the search results (i.e. number, study design, relevancy etc.) will be provided in the agile scope to help inform stakeholders.
3. Where little or no trusted secondary evidence exists, and if identified as potentially beneficial from the Medline search conducted in step 2, the scope may be extended, at the request of the stakeholder to include a search for systematic reviews or primary literature in Google Scholar, Scopus or Medline, as appropriate. At this and any subsequent step, quality assessment of the identified evidence would be required.
4. Primary studies are not usually included, unless few or no systematic reviews are identified in the preliminary phase of step 1, or stakeholders request it following earlier work they have undertaken.

Considerations

- The scope does not attempt to identify all evidence on a given topic.
- Not all outcomes identified in the literature will necessarily be included in this scoping report for a number of reasons, including:
    - Outcomes included in the scope are limited to those that are relevant to the stakeholders' original question.

[4] The sources on the Evidence Service list of trusted secondary evidence resources are provided in Appendix B, Table 1

- Outcomes may not have been reported in the secondary sources, although it may exist in the primary literature. These outcomes will therefore not be included within the scoping report.

- Findings within included reviews are not assessed for generalisability to the Welsh context. [*It would be a complex process as secondary evidence is likely to include studies from multiple countries.*] This would need to be considered by stakeholders if using secondary evidence to inform policy and practice. Additional work could be requested if necessary.
- The scope summarises the findings and conclusions of the source authors. If a specific element of the report is of particular interest, it is advisable to read the source(s) from which it originates in more detail, as this will provide more context. Further work may be undertaken on specific areas if required.
- Hyperlinks to the included evidence are provided in the data summary table. In many instances, that evidence is freely available. If not, your Trust's Knowledge and Library service can help. [NHS Wales Library Service | NHSWLS]

Methods

All agile scopes follow a broad methodology and structure, with only small variations according to the question and evidence base identified. Through discussions with stakeholders, a research question and inclusion/exclusion criteria are developed using the PICO/PECO format (population, intervention/exposure, comparator, outcome). **Note: stakeholders are requested to indicate evidence/information they have already identified.**

As noted above, the methodology utilised is designed to provide rapid information to stakeholders. In the first step, restricting the search to sources from the trusted secondary evidence resources list reduces the time taken both in terms of search scope and by excluding the need for critical appraisal.

The search strategy developed is based on the inclusion criteria and uses key words. The scope is restricted to including only English language evidence and publication date limits may be imposed when the search results are too large to manage in a short timeframe, or where the stakeholder requires work to be completed within a specific timeframe. Additionally, the countries included may be limited, particularly where generalisability to a Welsh context is a particular concern.

All search results and screening for relevant systematic reviews are maintained in an EndNote library or suitable reference management system. Inclusion at title and abstract are calibrated by two reviewers independently screening the first 10% to 20% of systematic reviews for relevance, with the remainder being screened by a single reviewer. Full text screening decisions are made by two reviewers. Data on study characteristics and findings relevant to the question are extracted by one reviewer and checked by a second. The evidence is them summarised narratively to answer stakeholder questions. Evidence gaps within the secondary literature are reported.

If none, or limited evidence is identified from the trusted secondary sources list, a brief search is conducted in Medline using basic key word searches to establish the benefit of conducting further searches in a broader range of databases. A summary of the search results (i.e. number, study design, relevancy etc.) will be provided in the agile scope.

Findings

The agile scoping report contains a narrative summary and a data table. The narrative summary is a broad overview of the evidence identified, with a particular focus on elements highlighted as important by stakeholders. Data tables include the reference, information on study characteristics and findings. The information in the data tables will vary according to the question, types of included studies and requirements of stakeholders. The table also includes a comment section highlighting any elements of particular interest to stakeholders along with any limitations that should be considered.

The report concludes with an 'options for further work' section. These suggestions are based on the evidence identified and provide an explicit rationale where further evidence review work is recommended. This information will be informed by the additional brief search conducted in Medline to help assess how much additional information, and the likely benefits of conducting additional work are. These findings will be provided to stakeholders to ensure they can make an informed decision on what to do next.

Appendix B: Search Appendix

Table 1 Resources searched	
Cochrane database of systematic reviews - https://www.cochranelibrary.com/cdsr/reviews *Systematic reviews on health care interventions, diagnostics and public health interventions.*	Date searched: May 2023
NICE – https://www.nice.org.uk/guidance *Guidelines of health care and public health topics. Note: you should be looking for systematic evidence reviews that may underpin guidance on your topic, not the guidance itself. Not all recommendations are based on evidence reviews.*	Date searched: May 2023
Joanna Briggs Institute - https://journals.lww.com/jbisrir/pages/advancedsearch.aspx *This organisation's journal, JBI Evidence Synthesis includes systematic and scoping reviews of both quantitative and qualitative evidence on healthcare and public health topics.*	Date searched: May 2023
Prospero – https://www.crd.york.ac.uk/prospero/ *Only need to look at the most recent protocols (last two years) as earlier protocols should have been published and will be found in other sources.*	Date searched: May 2023
National Institute for Health Research (NIHR) Public Health Research – https://www.journalslibrary.nihr.ac.uk/phr/about-the-phr-journal.htm *Some reports in this journal are systematic reviews of interventions to improve public health.*	Date searched: May 2023
The Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) – http://eppi.ioe.ac.uk/cms/ *Check the publications list for systematic reviews in the fields of education, health promotion and public health, as well as social welfare and international development.*	Date searched: May 2023
Campbell Collaboration systematic reviews - https://www.campbellcollaboration.org/better-evidence.html *Systematic reviews of the effects of social interventions in Crime & Justice, Education, International Development, and Social Welfare.*	Date searched: May 2023
What Works Centre for Wellbeing – https://whatworkswellbeing.org/about-us/ *Systematic reviews of the impacts of policies and projects on wellbeing.*	Date searched: May 2023
Early Intervention Foundation (EIF) – https://www.eif.org.uk/about *Systematic reviews about early interventions for tackling the root causes of social problems for children and young people.*	Date searched: May 2023
Health Technology Wales – https://healthtechnology.wales/ *Reports and guidance on use of medical devices, surgical procedures, psychological therapies, tele-monitoring or rehabilitation.*	Date searched: May 2023
Health Technology Assessments (Ireland) – https://www.hiqa.ie/areas-we-work/health-technology-assessment	Date searched: May 2023

Health technology assessments on the clinical and cost-effectiveness of drugs, equipment, diagnostic techniques and public health activities.	
National Institute for Health Research Health (NIHR) Technology Assessment (HTA) Journal – https://www.journalslibrary.nihr.ac.uk/hta/about-the-hta-journal.htm *Some reports in this journal are systematic reviews of interventions to, prevent and treat disease and improve rehabilitation and long-term care.*	Date searched: May 2023
Agency for Healthcare Research and Quality (AHRQ) Search Evidence-Based Reports | Agency for Healthcare Research and Quality (ahrq.gov) *Effectiveness and comparative effectiveness reviews of health care interventions.*	Date searched: May 2023
Scottish Intercollegiate Guidelines Network (SIGN) clinical guidelines – https://www.sign.ac.uk/our-guidelines/ *Clinical practice guidelines. Note: you should be looking for systematic evidence reviews that may underpin guidance on your topic, not the guidance itself. Not all guidance is based on evidence reviews*	Date searched: May 2023
The Collaboration for Environmental Evidence (CEE) *CEE seeks to promote and deliver evidence syntheses (systematic reviews and maps) on issues of greatest concern to environmental policy and practice, as a public service.*	Date searched: May 2023
Google Scholar – https://scholar.google.com/ *"private water supply" AND "health" AND "systematic review"*	Date searched: May 2023
Epistemonikos - https://www.epistemonikos.org/ abstract:(private) AND abstract:(groundwater OR well OR "ground water") AND abstract:(water *Search using keywords and select "systematic reviews" in the filter By Category menu in the results*	Date searched: May 2023
Medline – https://www.scopus.com/search/form.uri?display=basic#basic Private adj2 water AND health Private adj2 well AND health AND systematic review Also, searched for borehole, groundwater, rain, rainfall, storm, drought and flood* and climate change *Suitable for clinical/health related topics*	Date searched: May 2023

Appendix C: Data extraction

Table 2: Data extraction of the included primary studies (in alphabetical order)

Reference	Aim/Question	Abstract or summary	Comments
Ander EL, Watts MJ, Smedley PL, et al. (2016). Variability in the chemistry of private drinking water supplies and the impact of domestic treatment systems on water quality. *Environmental Geochemistry and Health*. 38, pp.1313–1332.	To help quantify human exposure to chemicals in private drinking water supplies in the UK and identify any potential public health risks, as part of Public Health England's (PHE) Environmental Public Health Tracking programme.	Study design: Cross-sectional survey. Location: Cornwall, England. Method: Tap water samples from 497 properties using PWS were collected across two phases: spring 2011 and 2013. Sampling design, sampling, data analysis and data reporting were undertaken by the British Geological Survey (BGS). Chemical variability was measured for 25 parameters as determined by PCV set by (DEFRA 2009)[5] and WHO guidelines (Smedley et al. 2014)[6]. Result: Sources of drinking water included: Boreholes 82% (n = 406), traditional large-diameter wells 12% (n = 62), spring capture 3% (n = 14) and unidentified source 3% (n= 15). Treatment could be recorded for 487 of the 497 (98 %) drinking water samples. Of these, 21% (n = 102) were untreated, and 47 % (n = 229) had no disinfection system in place using UV or, rarely, chlorination (n = 5). 65 % samples exceeded one or more chemical standards. The highest exceedances for health-based standards were nitrate (11 %), and arsenic (5 %). Other exceedance included pH (47 %), manganese (12 %), nitrates (11%), aluminium (7 %), iron (3 %) and nickel (3 %). Significant reductions in concentrations of aluminium, cadmium, copper, lead and/or nickel were found where households were successfully treating low-pH groundwaters, arsenic and nickel where treatment was installed for iron and/or manganese	Generalisability: The samples were collected from an area of metalliferous and arsenic mineralisation (Cornwall). Therefore, the reported findings could be generalisable to Wales; however, the contextual environment of the PWS in England needs consideration. Methodological rigour: This is a cross-sectional study and is therefore, susceptible to biases inherent to its study design. Randomised sampling was used to minimise sampling bias; however snowballing was also employed and therefore representativeness of the sample is not guaranteed. Water sample collection methods followed standard protocols used at BGS and the volunteer recruitment and appointment booking system was operated by PHE. Though self-reporting of treatment systems was used, criterion was used to

[5] DEFRA. (2009). *The Private Water Supplies Regulations 2009*. (Vol. Water, England. Statutory Instrument No. 3101).

[6] Smedley, P. L., Cooper, D. M., & Lapworth, D. J. (2014b). Molybdenum distributions and variability in drinking water from England and Wales. *Environmental Monitoring and Assessment*, 186(10), 6403–6416.

		removal, and arsenic where treatment specifically to decrease tap water arsenic concentrations was installed. However, 31 % of samples where pH treatment was reported had pH < 6.5 (the minimum value in the drinking water regulations), suggesting widespread problems with system maintenance. **Conclusion:** The degree of drinking water standard exceedances warrants further work to understand environmental controls and the location of high concentrations. The residents were more willing to accept drinking water with high metal (iron and manganese) concentrations than international guidelines assume. The findings point to the need for regulators to reinforce the guidance on drinking water quality standards to PWS users, and the benefits to long-term health of complying with these, even in areas where treated mains water is widely available.	assess the effects of pH adjustments on wider chemical properties. Chemical analyses were undertaken in accredited BGS Inorganic Geochemistry laboratories and recognised water quality guideline values were used. This study was a one-off survey conducted at two separate intervals: study authors assumed that variation within the dataset during the survey is substantially greater than variation in time.
Duke et al. (1996). A mixed outbreak of cryptosporidium and campylobacter infection associated with a private water supply. *Epidemiology and Infection*, 116(3), pp.303–308.	To describe an outbreak of gastroenteritis in which both campylobacter and cryptosporidium were isolated from the faeces of infected individuals, and where contaminated water was implicated as the vehicle of infection.	**Study design:** cross-sectional study **Location:** Northumberland **Method:** On the 20 May 1993, following request from a general practitioner, the Department of Public Health Medicine in Northumberland investigated an outbreak of gastroenteritis amongst residents of a mediaeval building, including 45 students and 9 tutors. The case definition was restricted to anyone resident in the accommodation wing who had developed symptoms of diarrhoea and/or vomiting in the week beginning 15 May 1993. The student residence was visited, and food histories were taken from symptomatic individuals. Stool specimens were collected and cultured for salmonella, shigella and campylobacter, and examined for cryptosporidium cysts. Water samples from the building were collected and examined for E coli, campylobacter, and cryptosporidium cysts. Following	**Generalisability:** The reported findings could be generalisable to Wales; however, the outbreak took place in 1993 in a mediaeval building in England and therefore contextual environment of the outbreak needs consideration. **Methodological rigour:** This is a cross-sectional study and is therefore, susceptible to biases inherent to its study design. The researchers provide results of an epidemic curve showing the number of cases per day and daily rainfall showing a possible association between rainfall, number of cases and the protective influence of sterilising water.

		indications of water-borne transmission, detailed inspections of water supply were undertaken. **Results:** This outbreak was attributed to water borne infection involving a PWS. In total, 200 residents were served by the PWS and the overall, attack rate of 22%. Analysis of stool specimens (n=20) identified 11 pathogens including Campylobacter *and* cryptosporidium. Water sampling identified high *E. coli* counts and further sampling suggested contamination in or near storage chambers. Investigations revealed the carcasses in a collection chamber connected with the water supply, and these, or run-off of slurry from surrounding fields, were the presumed source of contamination. Variation in the level of contamination were due to poor maintenance of UV treatment and untreated outlets. **Conclusion:** This outbreak highlights some of the difficulties associated with PWS including difficulty to achieve, maintain and enforce water quality standards in PWS because of their varied history and nature. Issues relating to the maintenance and monitoring of private water supplies are discussed. Problems with such supplies include old piping, proximity of livestock, inadequate knowledge of the layout and limited resources for monitoring and maintenance.	Study utilised various methods to collect data including validated and self-reported measures. Therefore, self-reporting bias is possible. Participant characteristics were not reported. Therefore, representativeness of the sample is not guaranteed in addition to risk of self-selection and non-response biases. Only a small number of faecal samples could be collected and analysed (n=20) and might affect reliability of the results. Authors did not report sponsorship/possible conflicts of interest, and therefore their potential impact is unclear. They also failed to identify limitations of own work, reflecting a lack of transparency as well as inability to demonstrate a comprehensive and holistic understanding of the research process and topic.
Harrison et al. (2000). Chemical Contamination of Private Drinking Water Supplies in the West Midlands, United Kingdom. *Journal of Toxicology:*	To collate data on chemical contamination of private drinking water supplies in the 13 health districts in the West Midlands, UK.	**Study design:** secondary analysis **Location:** West Midlands, England **Method:** The most recent year's data on the number of PWS, the number of supplies sampled, and the number and type of failures for chemical parameters were obtained from District and Local Authorities in the West Midlands Region. **Result:** Data covered 12-month periods during 1995–1996. Of the 6013 private supplies identified, samples from 1297 had	**Generalisability:** The samples were collected from West Midlands region. Therefore, the reported findings could be generalisable to Wales; however, the contextual environment of the PWS in England needs consideration. **Methodological rigour:** In the absence of a specific tool to assess quality of secondary analyses, we have used a

Clinical Toxicology, 38(2), pp.137–144.		been tested for chemical parameters during the period of the study. A total of 420 individual failures for chemical parameters were reported in 386 water supplies. The majority of breaches of UK and EU standards were due to increased concentrations of nitrate (270, 65% of failures), metals (81, 19%), nitrite (14, 3%), pesticides (6, 1%), and others (49, 12%). **Conclusion:** Over a quarter of the supplies tested during the period of the study were in breach of UK and EU legislation. Of the reported failures, the high concentrations of nitrate and nitrite, lead, copper and sulfate are of concern to health and remedial action is warranted. Regular sampling of private drinking water supplies remains necessary to prevent risk to health from a wide variety of toxic contaminants. **Note:** Since the publication of this study, the standards have been revised therefore, some findings may not fall within the current the guidelines.	generic tool for observational studies. However, we do understand that this tool may not be the most ideal. This is a secondary analysis of data and is therefore, susceptible to biases inherent to its study design. Although it uses data that were collected and analysed following standard protocols, it is limited by the biases and limitations of the methods used by the sources. Participant characteristics were not reported. Therefore, representativeness of the sample is not guaranteed in addition to risk of self-selection and non-response biases. It is unclear whether the survey utilised to collect the data were validated. Therefore, self-reporting bias is possible. Results for only a small number of PWS were available and therefore, representativeness of the sample is not guaranteed. Authors did not report sponsorship/possible conflicts of interest, and therefore their potential impact is unclear. They also failed to identify limitations of own work, reflecting a lack of transparency as well as inability to

			demonstrate a comprehensive and holistic understanding of the research process and topic.
Hoek et al (2008) Outbreak of Cryptosporidium parvum among children after a school excursion to an adventure farm, South West England. *Journal of Water and Health,* 6(3), pp.333-338.	To investigate the outbreak of Cryptosporidium parvum among children after a school excursion to an adventure farm, South-West England	**Study design:** cohort study **Location:** outdoor adventure farm in Cornwall, England. **Method:** A cohort study was implemented to investigate possible sources of infection during the farm visit following an outbreak among 35 people, (27 students and 8 teachers), who participated in a school excursion to an outdoor adventure farm in South West England, from 22 to 26 May 2006. Four stool samples were sent in from those who participated in school trip 2 and who had symptoms of illness. A standardized postal questionnaire was sent out to record symptoms, medical care, food and water consumption, and participation in the various activities organized during school trip 2. Only laboratory confirmed cases were included. Environmental investigation was undertaken to identify potential sources of infection and possible transmission routes. **Result:** Only 17 respondents matched the case definition and the attack rate was 85% with 100% attack rate in students and 50% in teachers. Single variable analysis of the completed questionnaires indicates several possible associations with illness. The most likely transmission route was contact with faecally contaminated surface water following heavy rainfall, or consumption of water from the private well. Disinfection of the water reservoir was by chlorination, to which cryptosporidium is resistant. **Conclusion:** This study highlights the fact that epidemiological investigations of outbreaks as a result of environmental exposures are complex but important to inform the public and health professionals of the risks posed by PWS and outdoor activities. This is particularly so after heavy rainfall, as this may	**Generalisability:** The reported findings could be generalisable to Wales; however contextual environment of the outbreak needs consideration. **Methodological rigour:** This is a retrospective cohort study and is therefore, susceptible to biases inherent to its study design. Study utilised various methods to collect data including validated and self-reported measures. Therefore, self-reporting bias is possible. To mitigate for bias, an objective measure of outcome was used. All participants of school trip 2 with eligible data were included so minimising risk of selection bias. Response rate for the questionnaires was moderate (74%). Authors did not report sponsorship/possible conflicts of interest, and therefore their potential impact is unclear.

		result in an increased effluent from faecally contaminated land, causing a wide variety of pathogens to wash into surface water and potentially, private wells. This pose risks for public health.	
Hunter et al. (2011). Quantitative microbial risk assessment of cryptosporidiosis and giardiasis from very small private water supplies. *Risk Analysis: An International Journal*, 31(2), 228-236.	To analyse regulatory sampling data from PWS to develop a quantitative microbial risk assessments (QMRA) model, which estimates the potential annual risk of infection with Cryptosporidium and Giardia.	**Study design:** development of risk assessment model utilising secondary data from observational studies **Location:** England and France **Method:** This risk assessment utilised a Bayesian belief network approach with Monte Carlo simulation. *E. coli* concentrations in PWSs were estimated using national surveillance data from England and France. The English dataset comprised of 34,904 separate microbiological samples collected from 11,233 PWSs submitted to Public Health Laboratory Service from 1995 to 2003. Whilst the French dataset comprised of 150,775 samples were extracted from 2,665 water supply systems serving less than 50 people, extracted from SISE-EAUX (the French Ministry of Health water quality database). For Cryptosporidium and Giardia, the data used were from the study of Kay et al. 2007. Drinking water consumption as well as the dose-response curves were obtained from the published literature. The estimated pathogen concentration, the risk of infection per day and annualised risks for one or more infections per year were calculated. And tornado graphs were derived to determine the impact of variation in the input variables. **Result:** The final regression model found that *E. coli* concentrations are significantly associated with concentrations of both *Giardia* and *Cryptosporidium*. This study found the risks of both *Cryptosporidium* and *Giardia* in very small water supplies to be very similar between France and England. The estimated risk of infection was very high with the median annual risk being of the order of 25–28% for Cryptosporidium and 0.4% to 0.7% for Giardia, though, in the poorer quality supplies the risk could be	**Generalisability:** The reported findings could be generalisable to Wales; however, the contextual environment of the PWS in England and France needs consideration. **Methodological rigour:** In the absence of a specific tool to assess quality of a risk assessment model, we have used a generic tool for observational studies. However, we do understand that this tool may not be the most ideal. This is a secondary analysis of data and is therefore, susceptible to biases inherent to its study design. Although it uses data that were collected and analysed following standard protocols, it is limited by the biases and limitations of the methods used by the sources. Participant characteristics were not reported. Therefore, representativeness of the sample is not guaranteed in addition to risk of self-selection and non-response biases. In addition to other limitations identified by the authors, they note that due to lack of sufficient information on the effects of seasonality on the variation of water

		much higher. For both pathogens, the main driver of variance in the estimated daily risk of infection is the uncertainty in the pathogen—*E. coli* regression constant. For *Giardia,* the second strongest driver is *E. coli* concentration while for *Cryptosporidium* the amount of unboiled tap water consumed is most relevant. For *Cryptosporidium,* the indicator *E. coli* concentration is relegated to third place, reflecting the weaker association between *Cryptosporidium* and *E. coli* in the regression model. **Conclusion:** The analyses presented here indicate a major risk of Cryptosporidium and Giardia infection in people consuming unboiled tap water from very small drinking water supplies. For those consuming water from supplies that averaged around the median risk, some 26% would expect at least one Cryptosporidium infection and 0.4% at least one Giardia infection in a year. Even among consumers whose supplies average around the lowest 5% daily risk, 3.5% would expect at least one Cryptosporidium and 0.05% at least one Giardia infection per year.	consumption behaviour and pathogen concentration in drinking water, this model assumes that risk does not vary seasonally.
Jones et al. (2005). Public perception of drinking water from private water supplies: focus group analyses. *BMC Public Health*, 5(1).	To explore the drinking water perceptions and self-described behaviours and needs of participants served by private water systems in the City of Hamilton, Ontario (Canada).	**Study design:** Focus groups **Location:** City of Hamilton, Canada **Method:** In September 2003, three focus group discussions were conducted; with English-speaking, Caucasian adult residents of the City who received their household water from PWS; two with men and women aged 36–65 years, and one with men and women 20–35 years of age. To identify residences with PWS, residential addresses were linked to digitized maps of the distribution areas served by the City's water treatment utilities within a Geographic Information System. Recruitment criteria used by a professional marketing firm for telephone screening and enrolment of participants was used and the focus groups were stratified with age. A trained facilitator moderated the discussions and an assistant recorded notes on the discussions.	**Generalisability:** The reported findings could be partially generalisable to Wales; however contextual environment of the PWS in rural settings of Canada needs consideration. Additionally, study included only English-speaking Caucasian adults. **Methodological rigour:** This is a qualitative study using focus groups to collect data and content analysis; and is therefore, susceptible to limitations inherent to its study design.

		Systematic procedures were used to help ensure reliability and validity of data collection and content analysis was used for analyses. **Result:** Overall, participants had positive perceptions of their private water supplies, particularly in the older age group. Concerns included bacterial and chemical contamination from agricultural sources. Testing of water from private supplies was minimal and was done less frequently than recommended by the provincial government. Barriers to water testing included the inconvenience of the testing process, acceptable test results in the past, resident complacency and lack of knowledge. The younger participants greatly emphasized their need for more information on private water supplies. Participants from all groups wanted more information on water testing, and various media for information dissemination were discussed. **Conclusion:** While most participants were confident in the safety of their private water supply, the factual basis for these opinions is uncertain. Improved dissemination of information pertaining to private water supplies in this population is needed. Observed differences in the concerns expressed by users of different water systems and age groups may suggest the need for targeted public education strategies. These focus groups provided significant insight into the public perception of private water supplies and the need for public health outreach activities; however, to obtain a more representative understanding of the perceptions in this population, it is important that a larger scale investigation be performed.	Full demographic and socio-economic characteristics of participants were not reported, thereby applicability might be limited. Setting of the focus group and potential power relationships were not explored, therefore, how these might have impacted the participant responses, cannot be ascertained. Data saturation was not achieved. Participants were incentivised for their participation. However, it is unclear what it was and how it might have motivated their participation. Authors did not include a reflexive statement of potential impact on participant responses. This was important as only one author analysed the data. Additionally, the quotations given had no tags so it unclear if these were representative of the data and selected fairly.
Kay et al. (2007). The microbiological quality of seven large commercial private water supplies in the United Kingdom.	This paper reports on intensive monitoring at seven commercial private water supplies (six of which	**Study design:** Time series analysis **Location:** England, Scotland, and Wales and one in Northern Ireland	**Generalisability:** The reported findings might be generalisable to Wales as two of the included seven PWS were from Wales whilst the rest were from other parts of the UK and therefore,

Journal of Water and Health, 5(4), pp.523–538.	were treated) spread throughout the UK serving hotels, holiday parks and food production enterprises.	**Method:** Seven private water supply sites were selected across the UK; two in each of England, Scotland, and Wales and one in Northern Ireland. Daily sampling of 'potable' water, both at the consumer tap and using large volume filtration for Giardia and Cryptosporidium spp. was conducted over two six-week periods in the spring and autumn of 2000; allowing for the effects of short-term episodic peaks in faecal indicator and pathogen concentration to be quantified. Samples were analysed for coliforms, Escherichia coli, enterococci, presumptive Clostridium perfringens and Campylobacter. Additional samples were taken for E. coli O157:H7. **Result:** A total of 1178 samples were analysed, mostly for bacteria and protozoan parasites. Each site was sampled on approximately 40 consecutive days over each of the two phases. All the supplies experienced intermittent pathogen presence and only one, a chlorinated deep borehole supply, fully complied with UK water quality regulations during both periods of sampling. Poor microbiological water quality typically followed periods of heavy rainfall. This suggests that the design and installation of such systems should be undertaken only after the likely range of raw water quality has been characterised, which requires a thorough understanding of the effects of flow and seasonality on raw water quality. There is no reason to suspect that the monitored sites are uncharacteristic of other commercial supplies and the results reinforce public health concerns related to domestic supplies. Furthermore, the pattern of contamination is highly episodic, commonly lasting only a few days. Thus, the relatively infrequent regulatory monitoring of such supplies would be unlikely to identify the poor water quality episodes and does not provide the data necessary for public health protection.	contextualising these would need further consideration. **Methodological rigour:** This is a time series analyses and is therefore, susceptible to biases inherent to its study design. It is unclear why the seven PWS were specifically chosen for the study, however as these were spread across UK, applicability is highly likely. Sample collection and analyses were conducted following standard protocol and using objective measures. Daily rainfall (mm) data were obtained for the UK Meteorological Office. Current standards for the coliforms, Escherichia coli, enterococci, Clostridium perfringens and Campylobacter were used to determine failure rates. Authors failed to identify limitations of own work, reflecting a lack of transparency as well as inability to demonstrate a comprehensive and holistic understanding of the research process and topic.

		Conclusion: The results of this study suggest that a risk assessment system similar to the WHO 'Water Safety Planning' approach might offer a more appropriate regulatory paradigm for private water supplies.	
Middleton et al. (2016). Prolonged exposure to arsenic in UK private water supplies: toenail, hair and drinking water concentrations. *Environmental Science: Processes & Impacts*, 18(5), pp.562–574.	The study aimed to assess exposure to inorganic Arsenic (As) via drinking water consumption in a population served by PWS in Cornwall, UK, using hair and toenail biomarkers.	**Study design:** cohort study **Location:** Cornwall, England **Method:** The sampling frame consisted of 476 households using a PWS that had provided drinking water samples for Ander et al. 2016- henceforth referred to as initial sampling (drinking water only). Information letters were sent and following telephone contact, 127 households were recruited to provide a follow-up drinking water sample in November 2013. Biomonitoring was conducted at time of follow-up. Sample collection packs were mailed to participants. Nail samples were self-collected by participants whereas hair samples were collected by researchers using an amended version of the COPHES project protocol. Additionally, an exposure/food frequency questionnaire was administered as well as data for drinking water related analysis and biomonitoring analysis along with information on the consumption of select dietary items that have been reported to contain As in relatively high concentrations. Amended versions of previously reported protocols were used to chemically analyse the samples and steps were taken to ensure quality control. **Result:** Strong positive Pearson correlations (r_p= 0.95) indicated stability of water As concentrations over the time period investigated (up to 31 months). Significant positive correlations were observed between drinking water and toenail ($r_{p=}$ 0.53; $p < 0.001$; 95% C.I: 0.43, 0.63) and drinking water and hair ($r_{p=}$ 0.38; $p < 0.001$; 95% C.I: 0.20, 0.53) As concentrations. Significantly higher As concentrations were measured in hair samples from males and smokers and As concentrations in toenails were negatively associated with age. A positive association between	**Generalisability:** The samples were collected from an area of metalliferous and arsenic mineralisation (Cornwall). Therefore, the reported findings could be generalisable to Wales; however, the contextual environment of the PWS in England needs consideration. **Methodological rigour:** This is a prospective cohort study and is therefore, susceptible to biases inherent to its study design. Recruitment was voluntary and sample size were not calculated. Therefore, representativeness of the sample is not guaranteed (26% of original sample) in addition to risk of self-selection and non-response biases. Study utilised objective methods to collect/analyse data, however adaptations were made. Additionally, it is unclear whether the questionnaires used to collect self-report data were validated. Therefore, self-reporting bias is possible. Authors did not report sponsorship/possible conflicts of interest, and therefore their potential impact is unclear.

		seafood consumption and toenail As and a negative association between home-grown vegetable consumption and hair As was observed for volunteers exposed to <1 As µg L^{-1} in drinking water. **Conclusion:** The temporal stability of As concentrations in PWS suggests that, for this particular region, measurements of As taken in the present are strong predictors of past levels of exposure dating back at least 31 months. Both toenail and hair biomarkers were susceptible to the influence of covariables on As concentrations. Although useful in assessing prolonged exposures to As from drinking water, other factors, such as diet, predominate where As concentrations in drinking water are low. A large degree of variation in toenail and hair biomarkers was still unaccounted for in this study, with exposure to soil and dust highly possible explanations in a region of well-documented elevated environmental As. Investigation into the significance of other exposure routes will be the focus of future research.	They also failed to identify limitations of own work, reflecting a lack of transparency as well as inability to demonstrate a comprehensive and holistic understanding of the research process and topic. As this study used data collected as part of another cross-sectional study Ander et al. as baseline, the limitations of the original study (reported earlier) need also be considered.
O'Dwyer et al. (2014). Microbiological assessment of private groundwater-derived potable water supplies in the Mid-West Region of Ireland. *Journal of Water and Health*, 12(2), pp.310–317.	To assess the microbiological contamination of groundwater as a function of both aquifer type and rainfall events in Ireland, using geographic information system (GIS) technology	**Study design:** time series analyses **Location:** Mid-West Region of Ireland **Method:** Private water wells (n = 125) were each sampled following standard protocol three times between 12 September 2011 and 12 November 2012 from all over the research area. Two factors, aquifer type and rainfall (mm), were chosen as independent variables that can affect the vulnerability of a groundwater body. Using a GIS, the relative hydrogeological and climatological features unique to each sampling location were derived. Utilising this information, a logistic regression model was used to predict the probability of contamination of PWSs with E. coli. The model contained two independent variables: rainfall (mm; $p<0.001$) and aquifer characteristics ($p = 0.001$).	**Generalisability:** The reported findings could be generalisable to Wales; however, the contextual environment of the PWS in Ireland needs consideration. **Methodological rigour:** This is a prospective time series analyses and is therefore, susceptible to biases inherent to its study design. Recruitment was voluntary, sample size was not calculated, and participant characteristics were not reported. Therefore, representativeness of the sample is not guaranteed in addition to

		Result: The full model, containing both predictors, was statistically significant at p<0.001, indicating that the model distinguished between the independent variables' relationship to the incidence of contamination. The results showed that 58.4% of wells (n = 73) were positive for E. coli at least once and hence failed to meet the legislative microbiological standards of the Drinking Water Directive 98/83/EC. Of the 125 PWSs analysed, 41.6% (n= 52) were found to contain none of the indicator bacterium E. coli. Of the 73 samples, 83.6% (n= 61) tested positive for E. coli at every sample event. The model identified rainfall as the strongest predictor of reporting contamination, with odds ratio of 1.173. This indicated that contamination was 1.173 times more likely with an increase in rainfall, controlling for aquifer in the model. The model indicated that contamination was 6.58 times more likely to be present in a karstified bedrock aquifer, controlling for rainfall in the model. In this model, rainfall (mm) demonstrates a higher odds ratio of 1.148. This suggests that in relation to bedrock aquifers containing either karstic or fissured flow regimes, the probability of contamination with E. coli is 1.15 times higher with an increase in rainfall. **Conclusion:** Contamination was above the national statistic of microbiological contamination in groundwater of 34% of routine sample. The occurrence of microbiological contamination was related to hydrogeological and climatological variables using LR. The LR model proved to be a potentially effective tool for the prediction of bacterial contamination in PWSs in Ireland and in similar regions, from a geological and meteorological perspective. This research suggests that households utilising a well water supply in areas where the underlying aquifer is overtly permeable, as in karst aquifer systems, are statistically more vulnerable to microbiological contamination and therefore appropriate guidance and source protection are recommended. Furthermore, it has been shown that precipitation also has a	risk of self-selection and non-response biases. Aquifer classification system developed by Geological Survey of Ireland and rainfall data from Irish Meteorological Office were obtained. Microbiological sampling and analysis followed US EPA approved kit and protocol. Authors did not report sponsorship/possible conflicts of interest, and therefore their potential impact is unclear.

		significant impact on the extent of faecal contamination with the likelihood of contamination increasing with successive rainfall episodes.	
Pollock et al. (2009). Spatial and Temporal Epidemiology of Sporadic Human Cryptosporidiosis in Scotland. *Zoonoses and Public Health*, 57(7-8), pp.487–492.	To identify possible associations between the cumulative incidence of sporadic C.parvym and C.hominis cases in Scotland at postcode sector level and a no. of explanatory spatial and temporal variables from 2005 to 2007	**Study design:** Time series analysis **Location: Scotland** **Method:** Only Sporadic cases of C. hominis or C. parvum infection in Scotland reported to UK Cryptosporidium Reference Laboratory from June 2005 to June 2007 were included in this study. Data were retrieved at postcode sector resolution on human population from 2001 census and on livestock population from DEFRA 2000 agricultural census. PWS data were provided by local authorities. For analyses, using area-based data, cases and human and livestock populations were assumed to be evenly distributed within a postcode sector. And for analyses using point patterns, cases occurring within a postcode sector were spatially referenced to the postcode centroid. **Result:** Of the 560 identified cases, 276 cases were C. hominis (49%) and 284 cases were C. parvum (51%). The highest incidence of both C. parvum and C. hominis was in children aged 0–4 years, with C. parvum predominating, although this was not statistically significant. There were differences between the two Cryptosporidium species in the time of year, at which the peak of number of cases occurs. C. parvum case numbers peaked in April and May, and C. hominis case numbers increased bi-modally in August and October. These increases in case reports were observed in the same months each year over the 2 years of data analysed in this study. The differences between months were significant (x^2 = 185, P-value = 0.00).	**Generalisability:** The reported findings could be generalisable to Wales; however, the contextual environment of the PWS in Scotland needs consideration. **Methodological rigour:** This is a time series analyses and is therefore, susceptible to biases inherent to its study design. Only included laboratory confirmed cases for which spatial and temporal reference data were available. Data on human population and livestock population were obtained from appropriate census data. Participation in the questionnaires used to collect these data is voluntary. Additionally, sample size was not calculated. Therefore, representativeness of the sample is not guaranteed in addition to risk of self-selection and non-response biases.

		C. parvum was more common in areas with lower human population densities, with a higher ratio of the number of farms to human inhabitants and with a higher ratio of the number of PWS to human inhabitants. It caused disease in humans in rural areas and in areas with high ruminant livestock density, whereas C. hominis was more common in the more densely human populated areas of Scotland. **Conclusion:** In postcode sectors where there was a lower human population density and a higher ratio of the number of farms to humans, there was an increased rate of C. parvum infection. These factors could both be considered as indicators of rurality. The higher ratio of PWS to human population was also a risk for increased cases of C. parvum. Drinking water contaminated with Cryptosporidium oocysts is a recognized risk factor for human illness, and inadequately treated PWS may pose a threat to public health in Scotland, particularly in more rural areas. Implementation of education programmes could reduce the risk of disease transmission.	
Reid et al., (2003). The quality of drinking water from private water supplies in Aberdeenshire, UK. *Water Research*, 37(2), pp.245–254.	To investigate the quality of drinking water from private water supplies in Aberdeenshire – data for Central and South Divisions from 1992 to 1998, and North Divisions from 1996 to 1998	**Study design:** secondary analysis of time series data with a sub-study of time series analysis of primary data **Location:** Aberdeenshire, Scotland **Method:** The quality of private water supplies within Aberdeenshire sampled between 1992 and 1998 was analysed with respect to the presence of total coliforms (TC), faecal coliforms (FC), and nitrate. Water quality data for Central and South Divisions were available from1992 to 1998 and those for North Division, from 1996 to 1998 from individual PWS registers from North, South and Central Divisions. Additionally, Category one F PWS were contacted and respondents were randomly selected and tested on three separate occasions within a year. Historic data for microbiological drinking water quality prior to 1994 and post 1994 were obtained and analysed using	**Generalisability:** The reported findings could be generalisable to Wales; however, the contextual environment of the PWS in Scotland needs consideration. **Methodological rigour:** In the absence of a specific tool to assess quality of secondary analyses, we have used a generic tool for observational studies. However, we do understand that this tool may not be the most ideal. This is study utilised primary and secondary analyses of time series data

		appropriate methods. Statutory limits by PWS (Scotland) regulations 1992 were used to determine failure rates. Result: Samples from Category two supplies had a higher failure rate (55%) than samples from Category one supplies (B35%) for coliforms. A total of 1100 samples were analysed for nitrate. The failure rate was smaller than for coliforms and generally greater for samples from Category one compared to category two supplies. The average nitrate concentration for samples from Category one E and F supplies was 32 mg l^{-1} with half the samples having a concentration >25 mg l^{-1}. The comparatively high average nitrate concentration is a consequence of the majority of PWS (91%) being located within a predominantly agricultural land-use area and is also typical of many surface waters in the region where increasing annual trends have been apparent.	and is therefore, susceptible to biases inherent to its study design. Study utilised previously collected data on water quality by the respective divisions as well as collection of water samples for further analysis for the sub-study. Although these were done following appropriate standards and water quality regulations, the reliability is limited by the biases inherent to the methods used by the sources. Though random sampling was employed for the collection of primary data for the sub-study, recruitment was originally voluntary. Additionally, sample size calculation was not reported. Therefore, representativeness of the sample is not guaranteed in addition to risk of self-selection and non-response biases. Water sample collection methods and analyses followed standard protocols and appropriate were used to ascertain failure rates. Authors did not report any potential conflicts of interest and failed to identify limitations of own work.
Risebro et al. (2012). Contaminated small drinking water	To investigate whether an elevated risk of infectious	**Study design:** Cohort study **Location:** East Anglia (Norfolk and Suffolk) and Herefordshire	**Generalisability:** The reported findings could be generalisable to Wales; however contextual environment of

supplies and risk of infectious intestinal disease: A prospective cohort study. *PLoS One*, 7(8), e42762.	intestinal disease (IID) exists in individuals who consume water from contaminated small supplies compared with those who drink from small supplies that comply with current standards and also whether this effect is modified by age.	**Method:** A prospective cohort study of 611 individuals served by a private supply in England was conducted. In Norfolk and Suffolk, recruitment occurred between January and December 2008 and follow-up completed in March 2009. In Herefordshire, recruitment occurred between October 2008 and September 2009 and follow-up completed in January 2010. Individual and household level data was collected via structured interviewer- and self-administered questionnaire. Water supplies received sanitary inspection and examination for indicator bacteria and participants maintained a daily record of IID. Regression modelling with generalised estimating equations that included interaction terms between age and indicators of faecal pollution was performed. **Result:** Crude IID prevalence was 9.3 days with symptoms/1000 person days (95%CI: 8.4, 10.1) and incidence was 3.2 episodes/1000 person days (95%CI, 2.7, 3.7) or 1.2 episodes per person year. Although there was no overall association between IID risk and indicator presence, there was strong interaction between age and indicator presence. In children under ten, relative risk (RR) of IID in those drinking from enterococci contaminated supplies was 4.8 (95%CI: 1.5, 15.3) for incidence and 8.9 (95%CI: 2.8, 27.5) for prevalence. In those aged 10 to 59, IID risk was lower but not statistically significant. **Conclusions:** Contaminated small water supplies pose a substantial risk of IID to young children who live in homes reliant on these supplies. By contrast older children and adults do not appear to be at increased risk. Health care professionals with responsibility for children living in homes provided by very small water supplies should make parents aware of the risk.	the PWS in England needs consideration. **Methodological rigour:** This is a prospective cohort study and is therefore, susceptible to biases inherent to its study design. Recruitment was voluntary and sample size was calculated and achieved despite low response and recruitment rate. However, representativeness of the sample is not guaranteed (11.4% of original sample) in addition to risk of self-selection and non-response biases. Study utilised objective methods for collecting data on exposure and self-report methods for outcome data. Therefore, self-reporting bias is possible.
Rutter et al. (2000). A survey of the microbiological quality of private	To collect results from regulatory microbiological testing carried out at	**Study design:** secondary analysis of data **Location:** Bristol, Manchester, Newcastle, Norwich, Nottingham, Poole, Preston, Reading and Surrey (England)	**Generalisability:** The reported findings could be generalisable to Wales; however, the contextual environment

water supplies in England. *Epidemiology and Infection*, 124(3), pp.417–425.	Public Health Laboratories to provide a national picture of the water quality from private supplies. Furthermore, this information was combined with background information on class, source, treatment and geographical location of supply to examine how these factors affected water quality.	**Method:** PWS were sampled by local authority in accordance with standard protocols. Sampling was carried out for `regulatory or routine', `follow-up', in response to previously positive samples, or `other' reasons, which included sampling in response to complaints. Water samples were examined for total coliforms and E. coli at Public Health Laboratories according to published standards. Results from the laboratory examination of samples from PWS, carried out between January 1996 and December 1997 were collected. Information was collected for coliform and E. coli contamination of PWS but detailed analysis of the results was only carried out for E. coli. **Result:** A total of 6551 samples from 2911 supplies was examined, over a 2-year period, of which 1342 (21%) samples, and 949 (33%) supplies on at least one occasion, failed current regulations for Escherichia coli. Total coliforms, including E. coli, were detected in 1751 (27%) samples from 1215 (42%) supplies. The percentage of samples positive for E. coli was highest in summer and autumn, and lowest in winter. Samples taken from larger supplies and from boreholes were less frequently contaminated than those from other sources. Chlorination, filtration or UV light treatment improved the bacteriological quality of supplies, but still resulted in a low level of compliance with the regulations. **Conclusion:** It is clear from this study that the general microbiological quality of PWS is poor in comparison with the public water supply. A risk-based assessment of the likelihood of faecal contamination might also improve water quality and aid health protection, as the current regulatory monitoring frequencies for the smaller supplies are clearly insufficient to ensure safe drinking water. In the short term, practical measures are also needed to improve the quality of PWS. Such measures should include informing and educating the owners and	of the PWS in England needs consideration. **Methodological rigour:** In the absence of a specific tool to assess quality of secondary analyses, we have used a generic tool for observational studies. However, we do understand that this tool may not be the most ideal. This is a secondary analysis of data and is therefore, susceptible to biases inherent to its study design. Although it uses data that were collected and analysed following standard protocols, it is limited by the biases and limitations of the methods used by the sources. Sample size was not calculated. Therefore, representativeness of the study sample is not guaranteed. Authors did not report sponsorship/possible conflicts of interest, and therefore their potential impact is unclear.

		consumers of PWS of the risks. There is also the need for further studies to assess the contribution of private water supplies to the incidence of intestinal infectious diseases in England and Wales. In particular, studies which show the degree to which PWS are contaminated with pathogens and epidemiological investigations to estimate the prevalence of disease in users of PWS.	
Strachan et al. (2011). The relationship between lay and technical views of Escherichia coli O157 risk. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 366(1573), pp.1999–2009. **Only data relevant to this agile scope has been extracted here. For further information, please refer to the full report.**	To understand the lay (accessible primarily through social science methodologies) and technical (via risk assessment and epidemiological techniques) views of the risk associated with the Escherichia coli O157 pathogen using two case study areas in the Grampian region of Scotland, and North Wales.	**Study design:** cross-sectional study **Location:** Grampian region of Scotland, and North Wales **Method:** Study areas were mapped and selected to offer a rural - urban contrast in E. coli O157 disease incidence. Human case data were obtained for North Wales for 1999–2007, totalling 250 postcoded cases; and for the Grampian region of northeast Scotland for the years 1997–2008, totalling 667 postcoded cases. The information from the National Public Health Service of Wales, Communicable Disease Surveillance Center, Cardiff, and from Foresterhill Hospital, Aberdeen on date of birth, postal district and date of reporting of each individual case was used in this study. A telephone-based exposure assessment questionnaire based on a sub-sample (n= 580) of the Grampian population stratified by age, population density and socio-economic status was carried out during the period September 2008 to June 2009. Awareness of, and attitudes towards, E. coli O157 risk in three equally represented groups from Grampian and North Wales: farmers, rural visitors and non-farming rural residents in the two study areas, (n= 900), was assessed using a paper-based, self-complete questionnaire. A multivariate linear regression model was developed to link together proxy risk factors, for each of the three primary transmission pathways: foodborne, waterborne, and environmental. And Quantitative	**Generalisability:** The reported findings might be generalisable to Wales as one of the studied regions was within Wales; however data from Scotland were also analysed and therefore, contextualising these would need further consideration. **Methodological rigour:** This is a cross-sectional study and is therefore, susceptible to biases inherent to its study design. Data for disease incidence mapping was obtained from National Public Health Service of Wales and Foresterhill Hospital in Aberdeen. Disease incidence calculation included both laboratory confirmed cases as well as those with links to a confirmed case within an outbreak. Recruitment was voluntary, sample size was not calculated, stratification was not explained, and participant characteristics were not reported. Therefore, representativeness of the

		microbiological risk assessment (QMRAs) for the pathways were developed. **Result:** Epidemiological risk factors of contact with farm animals, visiting farms or farm fields and having a PWS were associated with postcode districts of higher than average disease incidence in the human population. Estimates of risk factors using spatial epidemiology indicated that environmental and food sources were responsible for a higher proportion of cases than water from PWS. The relative importance of each exposure pathway was modelled, and results show that in Grampian, PWS use presented a 24.6% likelihood of transmission (95% CI 19.9 – 29.4) compared to main supply use at 3.5% likelihood (95% CI 1.7 – 5.3). In North Wales, the likelihood for PWS was 18.6 (95% CI 14.1–23.2) whereas main supply use had a likelihood of 8.0 (95% CI 5–10.9). The proportion of the population expressing a high knowledge of E. coli O157 was greatest in high-incidence disease districts compared with low incidence areas (17% vs 7%). However, no statistically significant difference was found between high- and low-incidence postcode districts in terms of the proportion of the population expressing a high likelihood of personal risk of infection (10% vs 14%), giving a counterintuitive difference between the technical (epidemiological and QMRA) and the lay assessment of E. coli O157 risk. **Conclusion:** Overall, the lay and technical views of the relative importance of different infection pathways showed a strong degree of consistency, although this was not the case between perceived personal likelihood of risk and living in an area of high risk. Integrative research incorporating both lay and technical views of risk is required in order that informed decisions can be	sample is not guaranteed in addition to risk of self-selection and non-response biases. It is unclear whether the self-reported questionnaires utilised to collect data were validated. Therefore, self-reporting bias is possible.

		made to handle or treat the risk by the groups concerned (e.g., the public, policy makers/risk managers, etc.).	
VanDerGeest et al. (2020). Private well stewardship within a rural, agricultural Latino community: a qualitative study. *BMC Public Health*, 20(1).	To examine the key factors impacting private well water testing behaviour among well water users residing in predominantly Latino communities in rural, agricultural areas	**Study design:** Focus groups **Location:** The Lower Yakima Valley (LYV) in Central Washington, USA **Method:** Four focus groups were conducted with private well users; 2 in Spanish and 2 in English. Latinos and non-Latinos (n=37) were recruited from a rural, agricultural community with a large Latino population and elevated nitrate concentrations in groundwater. A semi-structured interview guide was developed to capture factors impacting testing as guided by the Risk, Attitudes, Norms, Ability, and Self-Regulation (RANAS) Model and inductive thematic analysis was conducted by two coders to identify common themes. **Result:** Themes emerged around the factors impacting well stewardship, including well water testing, treatment, and maintenance, and were not specific to nitrate contamination. Private well users reported many of the same factors reported in other communities, with the exception of home repair experience and challenges around landlords and neighbours on shared wells, which have not been reported previously. In addition to landlords and neighbours, lack of actionable information, economic limitations, and lack of technical support emerged as factors that made well stewardship burdensome for individuals. The majority of participants reported using bottled water, including many who used point-of-use or point-of-entry water treatment systems. **Conclusion:** The burden of well stewardship in rural, agricultural Latino communities may suggest the need for interventions at the community, county, or state levels and not at the individual	**Generalisability:** The reported findings could be partially generalisable to Wales; however contextual environment of the PWS in rural settings of USA needs consideration. Additionally, study included Spanish and English-speaking Latino and non-Latino adults. **Methodological rigour:** This is a qualitative study using focus groups to collect data and thematic analysis; and is therefore, susceptible to limitations inherent to its study design. Full demographic and socio-economic characteristics of participants are reported, therefore applicability to Wales context can be determined. Authors note that saturation on the universal themes across all focus groups was reached but not on the differences between language groups. Participants were incentivised for their participation. However, authors did not discuss its potential impact on participants' motivation. Authors did not include a reflexive statement and potential power relationships were not explored, therefore, how these might have

		level alone. Additionally, the role of landlords, neighbours on shared wells, and home repair experience in well stewardship represent important areas of exploration for researchers and public health practitioners.	impacted the participant responses, cannot be ascertained. Authors identified some limitations of own work, reflecting a lack of transparency as well as inability to demonstrate a comprehensive and holistic understanding of the research process and topic.

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