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Research Paper

'They're telling us it's safe, but how do we know it's safe?' Different stakeholder perspectives on drinking water safety

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ABSTRACT

Current definitions of 'safe' drinking water and their inclusion in metrics for monitoring progress towards SDG 6.1 (universal access to safe drinking water) are inadequate as they fail to account for the way safety is understood and enacted in people's day-to-day lives. The aim of this study was to characterise the factors that influence what people understand by 'safe' drinking water and to identify opportunities to account for non-scientific/alternative ways of understanding 'safety' in the provision of drinking water. We used a case study from Scotland where residents have challenged water professionals over the safety of their drinking water. Semi-structured interviews ($n = 30$) were conducted with people involved in this case, and each participant was asked to draw 'safe drinking water'. Although many differences between the stakeholders were identified, the drawing exercise revealed that the residents and water professionals alike believed that consumer satisfaction was vital for believing it was safe. Overall, we found that different knowledge, priorities and epistemologies contributed to different perspectives on drinking water safety. In the future, we propose that more transdisciplinary and citizen-centric ways of working are adopted to improve outcomes in the pursuit of SDG 6.1.

Key words: experiential knowledge, safe drinking water, scientific knowledge, SDG 61, stakeholder perspectives, water justice

HIGHLIGHTS

- Scientific information is not necessarily used by the public to decide whether to drink water.
- Different forms of evidence are used to determine if water is safe to drink.
- Loss of trust in public institutions and 'experts' is also affecting the authority that water professionals have.
- Transdisciplinary and citizen-centric ways of working are needed to support the achievement of SDG 6.1 and water justice.

1. INTRODUCTION

Access to safe drinking water is crucial for human health (Bisung & Elliott 2016; Everard 2019; WHO 2022), and its importance is underscored by its ratification as a human right (UN 2010) and its inclusion in the UN's Sustainable Development Goals (SDG) (UN 2015). However, different definitions of safe drinking water exist and when these have been implemented through guidelines, targets and metrics, definitions have become complicated and are inadequate to genuinely support improved access to safe water (UN 2015; Guppy *et al.* 2019; WHO 2022). Furthermore, these definitions are technical in nature, formulated for the purpose of regulating and tracking progress on improving access to safe drinking water globally and do not necessarily reflect how people enact their own understandings of drinking water safety in their day-to-day lives (Mehta 2014; Chew *et al.* 2019).

The World Health Organization (WHO) offers guidelines for drinking water quality (GDWQ), which aim to support the development of drinking water regulations worldwide (WHO 2022). They refer to water that is free from contamination, propose maximum permissible levels of various parameters, and advise on contaminants, which are of significance to health (Guppy *et al.* 2019). The indicator used to monitor progress towards achieving SDG target 6.1 (which aims to achieve universal access to safe drinking water by 2030 (UN 2015)), suggests that safe drinking water means water that is 'free of faecal and

priority chemical contamination', which for the purpose of global monitoring means *E. coli* (or thermotolerant coliforms) and arsenic or fluoride where relevant (UN Water 2023). Understanding what constitutes safe drinking water is further complicated when data on water quality are not available to ascertain whether water is free from contamination, in which case access to an 'improved source' is used as a proxy (UN Water 2016). Not only have these approaches been criticised as insufficient for monitoring access to safe drinking water (Onda *et al.* 2012; Guppy *et al.* 2019; Germann & Langergraber 2022), but the number of different approaches highlights the ambiguity of what exactly safe drinking water means and to whom.

Furthermore, these definitions are disconnected from the way that people have been making decisions about the safety of their water for thousands of years. People have primarily used the aesthetic and sensory properties of water, which to some degree has helped to reduce the risk of waterborne illness (Hamlin 1990; Vuorinen *et al.* 2007; Spackman & Burlingame 2018). In many places around the world, people enact their own understanding of safety as it relates to drinking water. Many studies report that taste and odour are major influences on whether a consumer regards water as safe (Doria *et al.* 2009; Kot *et al.* 2011; Chew *et al.* 2019). Other factors are also important, including the experiences of ill-health because of consuming water (Francis *et al.* 2015), trust in the provider and familiarity with the water (Doria *et al.* 2009), cultural or religious associations with different water sources (Chew *et al.* 2019), as well as the participation and involvement of local people in the processing of the water (Marino *et al.* 2009). However, these non-scientific/alternative ways that people use to determine safety are not accounted for in drinking water guidance and regulation (WHO 2022).

It has been argued that the focus on scientific means of determining safety has led to a widening gap between regulators and consumers, which has negatively affected some communities (Kot *et al.* 2011). There have been cases when drinking water guidelines and proxies have been used to make decisions and to evidence drinking water safety, which has led to ill-health and water injustices (Mehta 2014; Clark 2020; Pauli 2019). For example, in Flint (Michigan, USA), in response to protests by people concerned about their water, city officials insisted that the drinking water supply was safe (Pauli 2019; Clark 2020). In reality, the residents of Flint were being supplied with water contaminated with lead, disinfection by-products and coliforms (Hanna-Attisha *et al.* 2016; Pauli 2019; Clark 2020). In another example from Gujarat (India), Vasava and Tadvi people were relocated from their ancestral homes due to reservoir flooding and were provided access to tap water (Mehta 2014). This was justified by officials based on the assertion that tap water was safe. However, the Vasava and Tadvi people reported the tap water was making them ill and was not always available, and further that they had been robbed of their river, which they regarded as holy (Mehta & Punja 2002). In these examples, water injustices were perpetrated against citizens when decision-makers followed 'expert' interpretations of regulations and guidance, whilst the lived experiences of consumers were marginalised.

Thus, scientific knowledge is prioritised both in global drinking water guidelines (WHO 2022) and in the way drinking water safety has been interpreted and decisions taken in practice (Mehta 2014; Clark 2020; Pauli 2019). In this paper, we consider not only the knowledge people have (e.g. scientific and experiential), but also *how* they know and enact that knowledge (epistemology) and explore how non-scientific/alternative understandings of 'safety' might be accounted for in decision making around the provision of drinking water. Using a case study in Aviemore (Scotland, UK) where the safety of drinking water has been challenged by residents, we aim to (i) characterise the factors that influence people's understanding of safe drinking water and (ii) identify opportunities to reconcile scientific and non-scientific/alternative perspectives on drinking water safety.

2. METHODS

2.1. Case study: Aviemore, Scotland

Scotland is reported to have already met SDG6.1 and is promoted as a 'Hydro Nation' by the Scottish Government with the quality of water resources 'amongst the best in the world' (Scottish Government 2012). Despite this, residents of Aviemore, a town in the highlands (North) of Scotland, have been concerned about the safety of their drinking water since the water source was changed in 2012 from a surface water source in Cairngorms National Park to a groundwater source. This change (affecting around 10,000 people and businesses) was made to better cope with a projected increase in demand for drinking water due to planned house building in the area. Residents were initially concerned about the taste and the smell of the water, although some were also concerned about the proximity of a landfill site to the abstraction points. To address the taste and odour concerns, the water professionals implemented a change in the disinfection process from chlorination to chloramination. However, residents became very concerned about the safety of chloramine as a disinfectant. In 2018, the residents presented a petition to parliament about the case, where the water professionals maintained that the water

met all regulatory standards. There has been no further documentation of this case since the news articles about the petition. This research focused on the understanding of drinking water safety of residents in the Aviemore water supply zone and water professionals with direct experience of the events that have unfolded there in the last decade. By focusing on an area where residents have had cause to engage with and confront localised water-related issues, it was hoped that it would be possible to tease apart the factors influencing the way safe drinking water is understood.

2.2. Data collection

We conducted 30 semi-structured interviews with people involved in the Aviemore case study. The selection of key stakeholders included in this research was informed by a review of the extant literature on this topic (see Supplementary material 1 for a full list of literature reviewed). These stakeholders included the water company responsible for supplying the drinking water and the drinking water quality regulator (collectively referred to henceforth as water professionals, $n = 7$), residents ($n = 22$) and a national park representative ($n = 1$). The national park representative's views were broadly aligned to the residents position and these groups were aggregated in interpreting the results, thus the resident group was considered to include 23 individuals. Purposive sampling was used in the first instance for all participants. Water professionals and the national park representative were recruited by directly contacting the individuals named in the literature and further water professionals were recruited using the snowball sampling technique (Bryman 2016) to reach others who had worked on the Aviemore incident. Residents were recruited by contacting all the community councils in the area affected by these events and asking them to nominate individuals to participate, or by contacting those named in news articles or other documents. The individuals who consented were then asked to propose further individuals, again using the snowball approach. The semi-structured interviews were conducted between June and August 2021. The purpose of the interviews was to gain an understanding of the factors that influence understanding of drinking water safety, by drawing on people's personal experience of when safety has been contested. The water professionals and one resident were interviewed online. The national park representative and all but one of the residents were interviewed face-to-face in cafes or at participants' homes.

Two interview guides were developed, one for each of the stakeholder groups, and questions based on some of the main issues and points of disagreement between stakeholders (see Supplementary materials 2 and 3), which were identified in the existing literature. At the start of every interview, participants were asked to give an overview of their experience of what happened before and after the water source changed. Next, every participant was asked to draw images of how they visualised safe drinking water. Drawing as a means of art-based research can be employed to bridge the gap between people with different educational backgrounds (Kearns *et al.* 2021). In this research, drawing was used to give the different stakeholders, with varying levels of science education and worldviews, a common language so that they were not restricted (or limited) by their knowledge of what safe water ought to mean.

As the interviews were semi-structured, not every participant was asked every question from the interview guide. This allowed participants to share what was most prominent in their recollection of the events to better understand what elements influenced their understanding of safe drinking water. This research was part of a larger study, which went on to look at how the events in Aviemore progressed and escalated and thus some questions were included for that work.

Residents have been assigned a number so that different residents can be distinguished across the Results section through the quotations. As there were fewer water professionals, to ensure anonymity, each quote has been given the more generic identifier of 'water professional'.

It is important to note that although we have designated these participants to Water Professional or Resident stakeholder groups, we do not claim that these groups are homogenous. The objective of this study is not to establish that one stakeholder group was correct, but to explore some of the different perspectives to find what the different perspectives are, why they exist and if different perspectives can be accounted for in decision making.

2.3. Data analysis

All interviews lasted between 1 and 2 h, were audio recorded and transcribed verbatim. The entirety of the interview transcripts were analysed using reflexive thematic analysis (Braun & Clarke 2022). We follow a qualitative paradigm for thematic analysis and thus do not believe there is a single correct way to analyse the data or an objectively accurate outcome from the analysis (as described by Terry *et al.* 2017).

Analysis began with a formal familiarisation phase by reading each transcript thoroughly and writing a reflective memo. Then an inductive open-coding process was initiated, which involved labelling individual words, phrases or sections of

text in the transcripts, according to thoughts or ideas the researcher had about the data and how it contributed to the experiences and understandings of the interview participants. The identification of the codes in the data was driven by the data and was not limited by any pre-conceived ideas or theory. This led to over 200 codes being developed in NVivo (v12) (See Supplementary material 4). Through several iterations of reading, engaging and coding, the codes were refined, and further reflective memos were written on an *ad hoc* basis as links and patterns across the data were identified. The initial codes then began to be grouped and 'thematic trees' (Miles & Huberman 1994) were created to explore relationships between different codes and from these trees, final themes were constructed.

As well as 30 interview transcripts included in this analysis, drawings were produced by 29 of the participants (1 participant declined to participate in this activity). The explanations participants provided for their drawings were included in the thematic analysis described earlier. The drawings themselves were also analysed using thematic analysis, using the text from the transcripts to aid interpretation (Bland 2012). Codes assigned to the drawings are included in the list of over 200 codes in Supplementary material 1. The codes from the interview transcripts and drawings were analysed together and both contributed to the development of the 'thematic trees' and construction of final themes.

The final themes identified and included in this paper highlight the different approaches participants used to come to a decision about the safety of drinking water. All steps outlined earlier were undertaken by the lead author and meetings were regularly held with the other authors to explore and discuss the data, the codes and themes identified and to consider how these related to the research question. Consistent with reflexive thematic analysis, we embrace the subjectivity of the analytical process (Braun & Clarke 2023) and seek rigour through active reflection, and adopting a systematic approach to analysis with deep engagement with the data (Terry *et al.* 2017).

2.4. Analytical approach and positionality

The overarching research paradigm adopted for this research is interpretivism, the goal of which is to understand how people construct meaning in their social setting (Neuman 2014). We contend that social reality cannot be observed objectively but must be interpreted through the interaction between social actors and examination of the meanings attributed by these actors (Corbetta 2011). Although we have interpreted the social reality experienced by all participants in this research as socially constructed, we do not imply that social reality is an illusion and acknowledge that these social realities are enacted as though they were objectively real and thus, have consequences (Neuman 2014).

In addition to our research paradigm, we are cognizant that our life experiences and values will also undoubtedly shape this research. The lead author is a former employee of the national water company and worked as a scientist in the laboratory analysing Aviemore samples at the start and through the peak of the events relating to the challenge over the safety of drinking water (2012–2017). She declared her prior involvement to all participants in the research and was grateful for the acceptance and openness of both the residents and the water professional participants. This research was approved by the University of Stirling's General University Ethics Panel (Approval number 2009).

3. RESULTS: WHAT DO PEOPLE UNDERSTAND BY 'SAFE' DRINKING WATER?

In total, 30 individuals were interviewed including residents ($n = 23$) and water professionals ($n = 7$). Three main themes were developed from over 200 codes (See Supplementary Material 4) and were taken forward for analysis in the subsequent sections (Table 1).

3.1. Evidence

The different stakeholder groups used different forms of evidence to inform their conceptualisations of drinking water safety. Although the term 'evidence' often refers to empirical data (Alasuutari 2010), particularly in relation to science, evidence by

Table 1 | Definitions of themes identified in transcripts relating to what people understand by 'safe' drinking water

Theme name	Theme description
Evidence	The information used by interviewees to justify their position or opinion on the safety of their drinking water
Indicators	Characteristics of drinking water, which interviewees considered when deciding whether drinking water was 'safe'
Mitigation	Actions taken by interviewees to mitigate the impact of the drinking water on their life

definition is broader and refers to information that supports decision making (Rycroft-Malone *et al.* 2004). Two primary forms of evidence were identified in the data that supported participants' understanding of the safety of their drinking water: science and personal experience (including sensorial information).

3.1.1. Science

Scientific evidence was generally prioritised by the water professionals. When discussing residents' complaints about skin irritation since the change in water source, one water professional said:

> *'This is where my scientific head comes in to say there's no link at all, especially at these low levels of hardness'* (Water professional)

They explained that scientifically, it wasn't possible that low hardness (mineral content) could be causing skin irritation, leading them to disregard this as evidence that the water was unsafe. Another drew pictures of test tubes and monitors (Figure 1) when they were asked to draw 'safe drinking water', which also illustrates the priority given to scientific evidence by the water professionals.

Some residents believed that the water professionals were claiming some intellectual authority by referring to science:

> *'You've got this rhetoric…scientific officers and the rest of it'* (Resident-8)

This implies that residents did not automatically trust the water professionals and some residents suggested that the water professionals were not using scientific evidence:

> *'I think they need to use the scientists a lot more'* (Resident-12)

This suggests that scientific evidence is valued by the residents, but that there needs to be more transparency around decision making and the scientific evidence used by water professionals needs to be more accessible to residents.

3.1.2. Personal experience

Residents explained that they used their personal experience to determine whether water was safe:

> *'I'm not a scientist or analyst, so I go by my experience.'* (Resident-8)

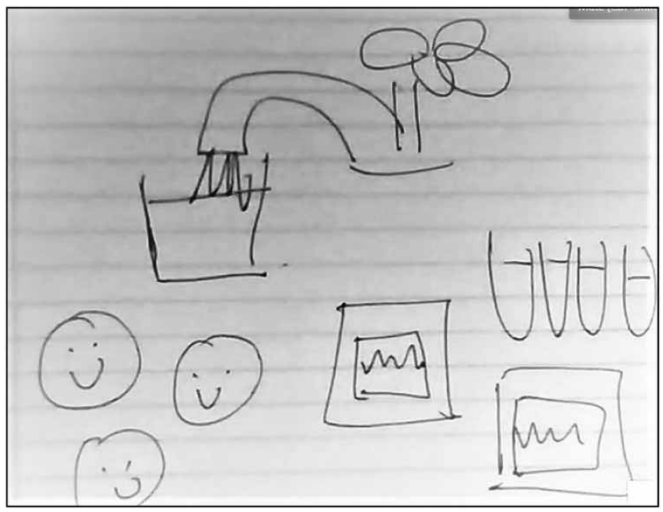

Figure 1 | Drawing by a water professional illustrating that test tubes and technical monitoring are important for their understanding of drinking water safety.

Many different experiences were shared during the interviews, which demonstrated the sorts of experiences residents were using to make decisions:

'The bloody cows werny drinking it.' (Resident-12, Figure 2(a))

'My skin is bad…it got so bad I went to see a specialist.' (Resident-20)'

'You can see inside the corrosion (showing photo, Figure 2(b)) and that's from the water. So, people are drinking that, now, I know they are falling ill as a result of it.' (Resident-11)

The water professionals recognised that if personal experience does not match what the professionals say, then it will not be convincing:

'*Me standing up and saying that the water is safe to drink didn't match their own personal experience of it…if you think it's making you ill every single day, then you're not going to believe me standing in front of you*.' (Water professional)

Many of the residents and water professionals drew smiley faces as part of the drawing exercise. This highlights that being happy with the water underpinned understanding of water safety. This suggests that personal experience is very important for understanding safety (Figure 3). One water professional said:

'*People need to be happy with it, including me as a [water professional] and customers need to be happy with it.*' (Water Professional, when explaining Figure 3(a))

Related to personal experience, sensorial information was also used to inform understanding of safety. Residents discussed all five senses as being affected by the water, including the taste, odour, appearance, feel and sound:

'The taste, the smell, I mean it was stinking.' (Resident-12)

'The general things in the household were kettles popping…' (Resident-24)'

'*When you boiled the [filtered] water up in the kettle, it stayed clear, whereas, when you filled it up without the filter, it looked cloudy.*' (Resident-17)

'*When you used to have a bath, you used to feel softer, and now there's just that kind of added, it's no the same, like, when you add your bubble bath. It's no the same, it doesnae lather the same.*' (Resident-9)'

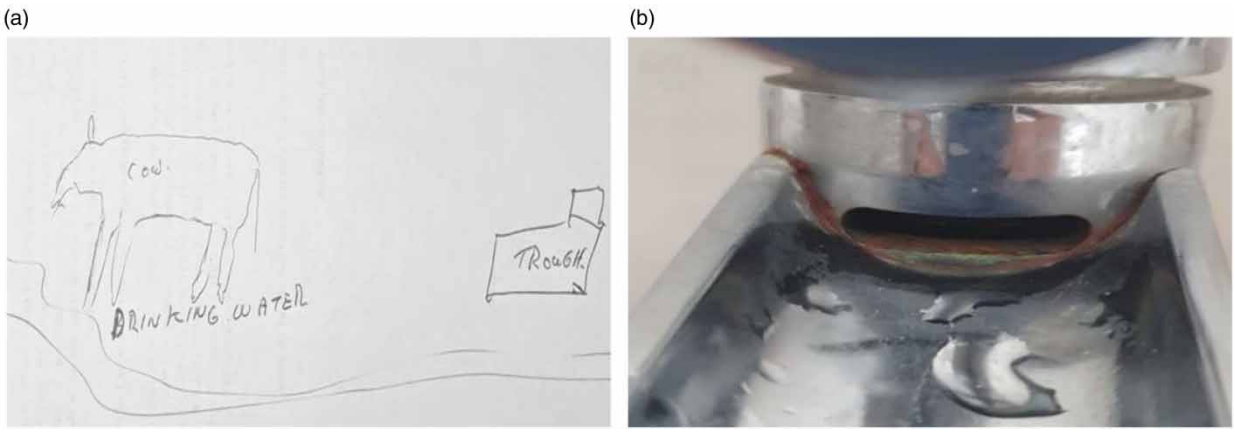

Figure 2 | (a) Drawing by one resident to illustrate that safe water to them looked like a cow willing to drink from the river, but not from the trough, which was filled with tap water (Resident-12). (b) Image shared by the participant of corrosion inside the tap (referred to in quote), presented as evidence that the water is not safe (Resident-11).

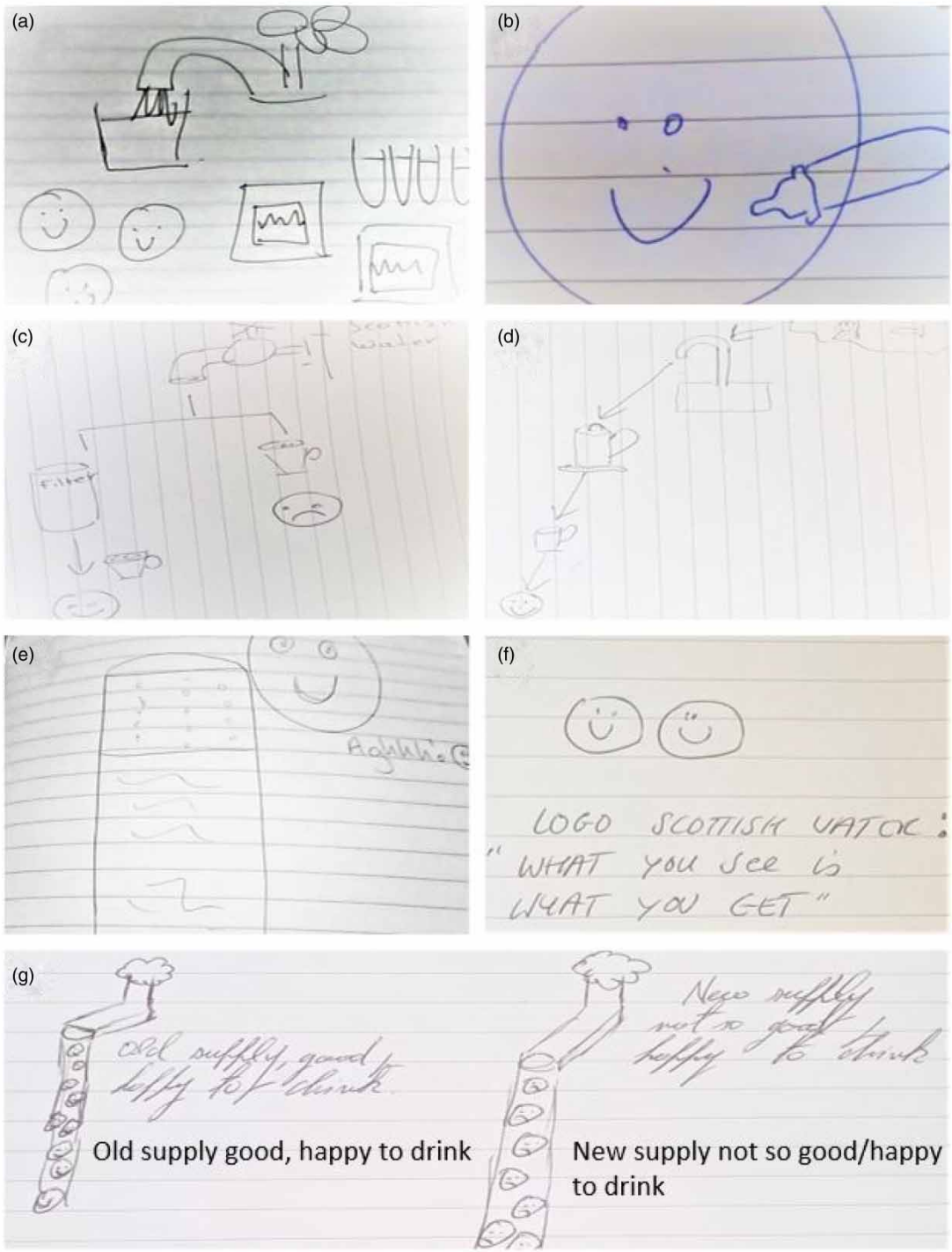

Figure 3 | Illustrations showing that happy or unhappy faces were consistently used to communicate satisfaction with the water across both stakeholder groups: (a) water professional (drinking water regulator employee), (b) water professional, (c) resident (Resident-6), (d) resident (Resident-4), (e) water professional, (f) resident (Resident-7), and (g) resident (Resident-8).

Sensorial information is included in Scottish drinking water quality regulations (The Public Water Supplies (Scotland) Regulations 2014) through taste, odour and turbidity tests, and thus is an important factor for understanding whether water is safe, whether the stakeholder prioritises scientific or personal experience evidence. However, sensory information

is subjective and the way it is communicated can also lead to different understanding. For example, the One Show (a British television chat show programme) took an interest in the events in Aviemore and arranged a blind taste test using Aviemore tap water and water from Salford (England, where the film crew were based). The residents reported that the Salford water was preferred:

'*They took mine, they took the Salford tap water and they taste tested the people down in Perth (Scotland) and everybody preferred the Salford water.*' (Resident-24)

However, a water professional reported that there was no difference in people's reactions to the two water samples:'

'The One Show [British chat show] did a blind tasting and the Aviemore water didn't jump out as being, you know…[different]' (Water Professional)

This highlights that even when a test was done to independently evaluate the water, the stakeholders still remembered and/ or interpreted the results differently. We did not try to verify whose recollection was accurate as the objective here was not to establish whether the water was safe or pleasant to drink, but to explore the different perspectives.

3.2. Indicator

As well as using scientific and/ or personal experience as evidence for the safety of drinking water, stakeholders also used other indicators to support decision making. Interviewees considered various characteristics of the drinking water itself, as well as its management. The main indicators identified here were: place (location of the water), source (whether the source is groundwater or surface water), treatment (whether the water is treated), trusted authorities (whose voice about the water is trusted) and participation (who is involved in decisions about the water). The drawings associated with these indicators can be viewed in Supplementary material 5.

3.2.1. Place

Many residents referred to water from the highlands of Scotland as being very pure and safe, with several explaining that they would be happy to drink water directly from the mountains.

'*People were very happy with the water supply, the quality of water. Up to that point there had never been any complaints…It was classic, pure highland water.*' (Resident-2)

This was reflected in many of the drawings by both stakeholder groups, which showed water running off mountains. This highlights that participants considered water that comes from the mountains and the highlands of Scotland to be intuitively safe to drink.

3.2.2. Source

Water from surface water sources, such as the original water source at Loch Einich, was considered much safer than groundwater sources, such as the new source at Kinakyle.

'*People just didn't like their highland loch source of their water being changed to underground, which is not as tangible.*' (Resident-2)

'We ended up calling it manky swamp water.' (Resident-24)

There was also concern among many participants that the aquifer supplying the drinking water may be polluted by the way the land is used. They were particularly concerned that leachates from a landfill site may be reaching the water:

'*Yeah, okay, there's a lot of good stuff that comes from the ground. But we're sticking a lot of shit stuff on it, you know the Granish dump is at the other end of Aviemore.*' (Resident-20)

This demonstrates that groundwater is seen as more obscure, less relatable and less 'known' by the residents, compared to their original water source.

3.2.3. Water treatment

Water treatment was used in different ways to denote safety. Water professionals regarded water treatment as important for understanding whether water was safe or not. Several water professionals commented that they liked to smell chlorine:

'I like to get a whiff of chlorine.' (Water professional)

However, many residents seemed sceptical of water treatment:

'*They're saying it's not safe to have no chemicals in it…I don't have any chemicals in my water [private water supply] and we're doing alright*.' (Resident-23)

This scepticism was illustrated in a drawing, which labelled treated water as unsafe and untreated water as safe (Supplementary material, figure 2). However, some residents acknowledged the importance of water treatment.

3.2.4. Trusted authorities

Different people with authority influenced the residents in different ways, depending on whether residents trusted them. For example, many of the residents believed and felt validated by Erin Brockovich (renowned environmental activist who successfully built a case against a water polluter in the USA and is the protagonist of the film of the same name (Brockovich 2021)), when she spoke out in support of the Aviemore residents. Her statement of support was used by residents to validate their concerns:

'It's a chemical cocktail like Erin Brockovich said.' (Resident-24)

This was a major concern for the water professionals who said:

'Celebrity-driven news versus science-driven news. I know I'm always going to lose out there.' (Water professional)

This highlights a tension between different sources of information, trust and authority, which have the potential to influence understanding of drinking water safety.

3.2.5. Participation

Involvement in decision making related to water also influenced trust in the safety of the drinking water. There was frustration among residents at the lack of involvement of the local community.

'*There was no communication…I think they said it would [worry] people about giving us information beforehand*.' (Resident-10)

Another resident reflected on their previous involvement in decision making processes and described that:

'*there's nothing to beat doing a lot of consultation and very early on… organizations, local people… listen to what people were saying…set them up into discussion groups to solve problems…they felt that they'd been listened to*.' (Resident-21)

This participant suggested that participating in decision making can improve relationships and project outcomes. When people are not involved in decision making, their exclusion can be viewed suspiciously which then influences their trust in the decisions made about them, in this case in the safety of their drinking water.

3.3. Mitigation

Many residents in this research reported taking mitigation measures to cope with what they deemed to be their unsafe drinking water supply. The three main mitigating actions included the use of water filters, collecting water and bottled water.

3.3.1. Filters

The most common mitigating action reported by residents was the use of water filters to improve the taste of the water and to remove anything that might be causing them harm:

'We filter the water, and the problem is really solved as a matter of fact…' (Resident-6)

These filters ranged from filter jugs to larger table-top systems, to inline filters which filter all water coming into the house.

3.3.2. Collection

Another common mitigating action reported by residents was the collection of water perceived to be safe. Residents explained that they would collect water from Loch Einich, the original water source, which is a 14-mile round trip by bike or foot (there is no public vehicle access road). This is depicted in a drawing by one resident (Figure 4). Others reported that people collect water from private springs or from other private water sources at workplaces.

'*If I'm at Loch Einich on my bike, I'll fill everything I can to take home with me.'* (Resident-19)

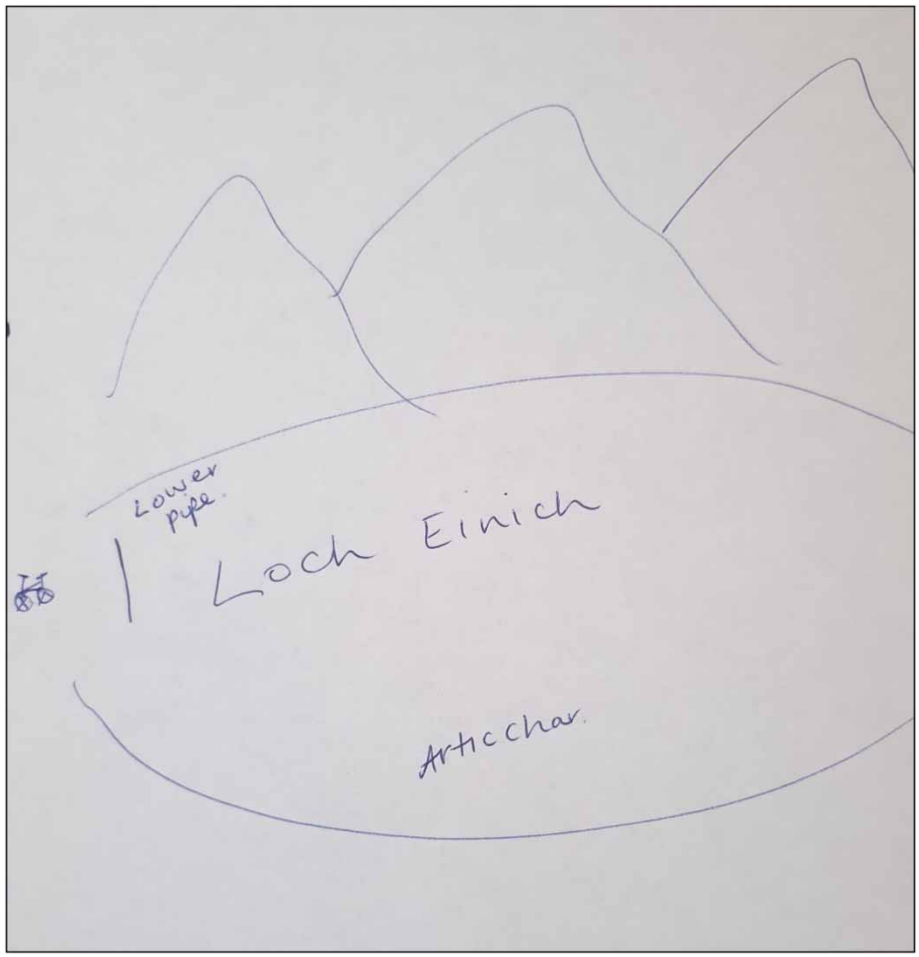

Figure 4 | Illustration by a resident-23 showing that they cycle to Loch Einich and collect water.

'*Every day, even to this day, I have a whole crowd of people who come and fill up at my tap [private water source] with their big containers.*' (Resident-23)

When participants were asked if they filtered the water they collected from these sources, residents responded that they didn't think it was necessary:

'*You don't have to filter that [water collected from Loch Einich] I don't need to use it [Filter jug], I pour it in the kettle straight away.*' (Resident-19)

This is consistent with the residents' scepticism of water treatment, discussed in Section 3.2.

3.3.3. Bottled water

Several residents mentioned that they use bottled water for drinking water purposes:

'*We go through four great big two and a-bit litre bottles of water everyday at least…' (Resident-4)*

Buying bottled water was the only mitigating action that water professionals mentioned being aware that residents were taking:

'*Some customers in Aviemore certainly report that they unfortunately feel compelled to drink bottled water as a result of their misgivings about the public water supply.*' (Water professional)

This mitigating action is one that is likely adopted by many people across the country (Water UK 2019), but in Aviemore it is seen as a burden when they would rather drink tap water.

4. DISCUSSION

This research aimed to characterise the factors that influence people's understanding of safe drinking water and to identify opportunities to account for non-scientific/alternative ways of understanding 'safety' in the provision of drinking water. To understand how non-scientific/alternative understanding of safe drinking water might be accounted for, we consider why that has been challenging in this case study. This discussion explores, first, why people viewed the same drinking water so differently; second, how the relationship between stakeholders was undermined by a mutual lack of respect; and third, considers the impact of the loss of trust in the 'experts'.

4.1. The tension between scientific and experiential knowledge

A key issue highlighted in this research was the tension between experiential and scientific knowledge. To clarify the terminology used, here we consider that 'knowledge' encompasses both evidence and information (as discussed by Dammann (2018)) and reflects both the evidence and the indicators used by the stakeholders and identified in Sections 3.1 and 3.2.

This tension was evident as both stakeholders seemed surprised that anybody could dispute their perspective on the safety of the water. As Pope & Gilbert (1983, p195) said when discussing the construction of scientific knowledge: '*It is assumed that everyone perceives phenomena in the same way and that facts are seen as static entities*'. This is perhaps the crux of the dispute that emerged from this case study and is consistent with our interpretivist paradigm, which asserts that individuals' social worlds affect the meaning they ascribe to their experiences (Neuman 2014). In other words, depending on their social experiences, individuals will perceive the same phenomena in different ways.

In this example, residents' knowledge was based on their experience and information about the water (indicators). For the purposes of the analysis and interpretation, we are also considering sensory knowledge as being experiential in nature. Sensory experience is regarded as being a foundation of knowledge (Craig 1976). Nevertheless, sensory knowledge is afforded different priorities in different cultural contexts (Strang 2005). In this case, residents regarded their sensory experience as obvious and unequivocal evidence that the water was unsafe, whilst the water professionals regarded sensory experience as unreliable, with respect to drinking water regulations.

These different forms of knowledge privileged by the stakeholders affect their subsequent actions and roles in this case. The water professionals made decisions, which ensured that the water was compliant with the regulations (Water (Scotland) Act 1980), as was their priority. However, this focus neglected other perspectives on safety. The residents' priority, as is clear from the mitigation actions they took, was to have water that was aesthetically satisfying, minimally treated and aligned with their place-based attachment to the highlands of Scotland and to their original mountain loch source. It is important to note that although participants' perspectives on what safe drinking water means were remarkably consistent within the stakeholder groups, there was some acceptance in each stakeholder group of the others' perspectives. One water professional believed that there was a problem but did not believe the water was non-compliant or unsafe; and some residents believed that the water was compliant with regulations but did not believe it was safe. Therefore, although the stakeholder groups at times appeared to be entirely opposed, there was understanding between the groups.

However, overall, the stakeholders prioritised different knowledge and took action on that basis. This mirrors the challenge highlighted earlier that drinking water regulations, targets and guidelines do not necessarily account for the way water safety is interpreted and enacted in people's day-to-day lives (Mehta 2014; Chew *et al.* 2019).

4.2. Misinformation or epistemic choice?

Both stakeholder groups contend that their position on what drinking water safety means represents 'reality', that the water is or is not safe. Although water professionals consider consumer satisfaction to be important for understanding safety, they primarily use scientific water quality data because they believe that the scientific data 'describes what is there' (Blaikie & Priest 2017, p54). They come to 'know' that the water is safe based on their interpretation of these data. Thus, they are making an 'epistemic choice' (Ostrom 1993) about what they understand by 'safety'. The residents come to 'know' and understand 'safety', based on their senses, personal experience, values and their (mis)trust in authority figures.

This framing of knowledge and the choice of how things come to be known (epistemic choice), which precedes decisions taken based on that knowledge, challenges the popular notion of misinformation. Misinformation is described by Lazer *et al.* (2018) as false or misleading information, which does not reflect the true state of the world (Cook *et al.* 2015). The water professionals, when discussing the power of the renowned environmental activist Erin Brockovich, in validating the concerns expressed by the residents, referred to the danger of celebrities spreading misinformation (Iammarino & O'Rourke 2018). However, this highlights the challenge of reaching an agreement when different groups have different worldviews. An interpretivist research paradigm (as adopted here) suggests that social reality does not exist independently of the social actors, but is produced, reproduced and interpreted through their interactions (Corbetta 2011; Blaikie & Priest 2017). This was also demonstrated when the stakeholder groups recollected different outcomes from the One Show's blind taste test. This suggests that trying to verify the safety of the water is not sufficient to reconcile the different perspectives by proving one 'true' answer. Thus, what appears as misinformation to one group may appear to be rational evidence to another (Eyal 2019).

In this example, the water professionals who discussed the spread of misinformation were specifically disputing the concerns about the safety of the disinfectant used as part of water treatment for water supplied to Aviemore. However, the safety of this disinfectant has been the subject of scientific investigation in recent years (e.g. Postigo *et al.* 2021; Wastensson & Eriksson 2020). Likewise, the residents believed that the problem was self-evident and were sceptical that the water professionals did not experience the water in the same way. This highlights a further relational challenge between the stakeholders. Not only do they privilege different forms of knowledge, but there is also a lack of respect between the stakeholders and the perspectives each holds.

4.3. Expertise and trust

Usually, citizens trust experts to make decisions on their behalf and trust institutions and policies to protect them from harm (Baghramian & Croce 2021). In the case study described here, there was a disruption in the usual direction of trust in society, when the expertise of the water professionals conflicted with the residents' personal experiences. Trust is an important mediating factor in the evaluation of good water governance (Voogd *et al.* 2022) and the acceptance of drinking water (Bratanova *et al.* 2013). Indeed, the tagline for Scotland's national water company is 'Trusted to serve Scotland'. This demonstrates a recognition that trust is fundamental to the role of the company.

The lack of trust in the water professionals, discussed here, reflects challenges increasingly faced by public institutions globally with a decline in social capital and a more polarised society (Aldrich & Meyer 2014; Lewandowsky *et al.* 2017). The COVID-19 pandemic, which saw many different types of experts forced into the public spotlight, created a stark opportunity

for citizens and government to confront, react and sometimes weaponise expertise for personal decision making and political gain (Mihelj *et al.* 2022; Yuen 2023). Thus, although historically citizens at large could have been expected to trust experts implicitly (Baghramian & Croce 2021; Liao 2021), organisations are no longer able to take that trust for granted. It may be that in the past the water professionals' authority on the safety of the water would not have been questioned, but as this case shows, residents will not necessarily take this authority at face value.

However, the portrayal of those who mistrust the experts as mistaken, or as somehow lacking, ignores the vulnerability of those who must entrust experts (or other knowledge-holders) and the consequences of perceived betrayal of that trust (Scheman 2020). In this case study, prior to the problems with the water, residents had had little cause to question their implicit trust in the water professionals. It was only when their trust was perceived to have been betrayed that those different ways of knowing (epistemologies) began to emerge. To ensure that regulations, targets and GDWQ are effective and reflective of the way drinking water safety is understood and acted upon, these different epistemologies must be accounted for, and trust restored in those making these decisions.

4.4. Study limitations

This study has some limitations; it is important to consider in understanding the findings. First, our resident sample selection was biased towards those who expressed concerns about the drinking water. This was partly because we recruited participants through community councils or by contacting them directly if their names appeared in any news articles or other documents about the case. These people were therefore more likely to be those who were concerned. We tried to reach those who were not concerned through snowball sampling and declaring an interest in speaking to those people. This was somewhat effective, and we reached three people who at the recruitment stage said they were not concerned about the water, but in all three cases, it transpired that they either didn't drink the tap water or filtered it. More direct engagement with the community (i.e. leafleting or cold calling) might have reached residents who had no concerns. However, the objective of this research was not to obtain representative perspectives of each of the stakeholder groups, but rather to consider perspectives that were conflicting and led to challenges in this case, which this research has done.

Another factor to consider is that these data were collected in 2021 but concern about the drinking water first surfaced in 2012. It was clear that some memories of the event for both water professionals and residents had faded. Many water professionals struggled to remember when specific events occurred and had to refer to notes or other documents. The difference between stakeholders' explanations of the One Show blind taste test also suggests that over time details may have been forgotten. Although there were specific instances when memories appeared to be unreliable, the consistency between participants in the stakeholder groups as well as the review of the documents before the interviews provided some reassurance of the accuracy of events and decision making discussed by participants.

Despite these limitations, using semi-structured interviews enabled us to have open conversations with participants. Both stakeholder groups found this an emotive topic, and some felt their lives had been markedly changed by these events. The semi-structured interviews allowed the events and associated decisions to be discussed in-depth and to be dealt with sensitively.

5. CHALLENGES OF ACCOUNTING FOR NON-SCIENTIFIC/ALTERNATIVE KNOWLEDGE AND RECOMMENDATIONS

Previously, we listed findings by other authors which highlighted some of the factors affecting people's understanding of drinking water safety, including personal experience, trust in the provider, familiarity with water, cultural or religious associations and involvement of local people (Doria *et al.* 2009; Kot *et al.* 2011; Marino *et al.* 2009; Francis *et al.* 2015; Chew *et al.* 2019). Our research is consistent with these findings and concludes that taste, odour, trust, personal experience and cultural relationships with water (place-based attachment) are important for individuals to understand whether their drinking water is safe or not. We find that in Scotland, a relatively water-rich country (Greig & Rathjen 2021), there are contentions over what safe drinking water means and whether it is universally acceptable. Crucially, understanding of safety is influenced by factors beyond those which are scientifically measurable. However, whilst the differences in what is understood by 'safe' drinking water between stakeholders were very evident, there was a key commonality between stakeholders, which emerged through the drawing exercise. Both residents and water professionals conveyed that the satisfaction of the consumer is key to determining whether water is safe to drink. The use of the drawing exercise broke down conventional knowledge and associated language barriers (Kearns *et al.* 2021), to enable this finding to be identified. Thus, reconciliation between these stakeholders'

views will be contingent on acknowledging and incorporating this commonality, while addressing the identified challenges, i.e. reconciling different knowledge and priorities and overcoming mistrust between stakeholders.

The first challenge, reconciling different knowledge and priorities (discussed in Section 4.1), can be approached by attempting to integrate the scientific and experiential knowledge held by the stakeholders. Here we do not suggest a need to reconcile different epistemologies because in line with our interpretivist approach to this research, we do not believe that there is one correct reality or way of knowing, but that different knowledge and priorities can co-exist with acknowledgement and recognition of other stakeholders' views. Experiential knowledge has been recognised as complementary to scientific knowledge and is crucial for timely and effective decision-making (Fazey *et al.* 2006). Had the residents' experiential knowledge been acknowledged and accepted as valid and not contradicted or underestimated, work to develop a mutually acceptable resolution may have begun earlier and may have been more successful. This challenge was also seen in Flint (Michigan) when the experiential knowledge held by residents was initially undermined by the scientific data, which was interpreted by experts to conclude that there were no problems. However, retrospective analysis suggested that was an erroneous conclusion (Roy *et al.* 2019). Both examples highlight the complexity of knowledge production, assimilation and application, as both experiential and scientific knowledge are subject to interpretation (Fazey *et al.* 2006; Eyal 2019).

This leads to the second challenge, that stakeholders in this research generally did not trust or respect each other's perspectives (discussed in sections 4.2 and 4.3). The residents' views were regarded as unscientific and based on misinformation, the water professionals' views as dishonest. Carlsson *et al.* (2023) call for the recognition of multiple epistemologies and Lewandowsky *et al.* (2017) suggest this might be addressed by taking multi-disciplinary approaches. We take this a step further and argue that before knowledge can be integrated, and 'multi-disciplinary approaches' pursued, for the reconciliation of knowledge and between holders of different knowledges, disciplinary epistemologies must be interrogated. We propose that for an understanding or definition of safe drinking water to be mutually acceptable, practical and implementable, it will be necessary to break down and then co-create a new way of thinking, which acknowledges these different perspectives. In other words, that stakeholders endeavour to understand not just what the other stakeholders know, but why they think that and work co-operatively from that point. Thus, we advocate for more than multi-disciplinary approaches, but rather, for the adoption of transdisciplinary research approaches, and the implementation of policy and regulations, which are underpinned by transdisciplinary ways of thinking. We propose that only then will different knowledge be reconciled with more just outcomes for all stakeholders.

These challenges and recommendations are relevant at all levels, from the provision of drinking water at a local level (as in this case study) to the decision-making about provision nationally and internationally. The WHO's GDWQ states that the guidelines should be adapted to suit local circumstances, to suit social, economic and environmental conditions (WHO 2022). We suggest that this adaptation should explicitly seek to acknowledge and integrate different understandings of safety, and a solution co-developed between different knowledge-holders. Although measuring progress towards SDG 6.1 in effect requires a universal definition of safety, those responsible for delivering improvements must acknowledge different knowledge and ensure that any 'improvement' is mutually acceptable. Furthermore, those monitoring and reporting on progress should be mindful that providing an 'improved source' does not necessarily mean that the source will be used for drinking water purposes or that the water users will be protected from ill-health as they may continue to use alternative sources.

6. CONCLUSION

In this paper, we identify several factors that influenced what people understood by 'safe' drinking water and how they enacted their understanding. Our findings suggest that different stakeholders in society have fundamentally different knowledge, priorities, and epistemologies, which influence their understanding of what safe drinking water is and can cause conflict and mistrust. Despite these differences, in the case explored here, the stakeholders agreed on the importance of consumer satisfaction for the water consumed to be considered safe. These findings present a starting point for the integration and reconciliation of different perspectives.

Water injustices have been experienced by citizens across the world where those in positions of power have taken unilateral decisions, reportedly based on scientific evidence to supply drinking water and protect consumers from harm. The research discussed here and elsewhere highlights the importance of involving citizens in decisions and changes that affect them and acknowledging their knowledge, experiences and perspectives. As Sultana & Loftus (2020, p11) argue: '*The*

right to water is not just about quantity, quality, availability, or access, but fundamentally about the right to participate in water governance and power structures that influence those rights.' Achieving SDG 6.1, delivering on the human right to safe drinking water and embedding justice in water governance depends on reimagining what constitutes water knowledge and how it should be implemented.

AUTHOR CONTRIBUTION STATEMENT

The authors confirm their contribution to the paper as follows: HA, HP, RQ rendered support in study conception and design; HA collected the required data; HA, HP, RQ analysed the data and interpreted the results; HA drafted the manuscript. All authors reviewed the results and approved the final version of the manuscript.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.;.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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