Consumer perception and understanding of the risks of antibiotic use and antimicrobial resistance in farming

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Abstract

To combat the OneHealth threat of antimicrobial resistance (AMR), the use of antibiotics in agriculture is subject to significant governance-led initiatives to change food system behaviours, including promoting more responsible use of antibiotics on farms through market-level interventions. To combat knowledge gaps about how consumers perceive risks associated with antibiotic use and AMR in farming, the current study carried out an in-depth qualitative focus group study incorporating a risk information exposure exercise with food consumers on the island of Ireland (n = 36). Using a theoretical lens of social representation theory, a thematic analysis of the collected data identified how participants made sense of, often new, information on agricultural antibiotic use and AMR. Participants displayed high awareness and concern for AMR but low understanding and misconceptions around AMR transmission from the agri-food sector. Social representations about antibiotics and food and farming systems shaped preferences for a movement away from antibiotics in farming, and in particular, prophylactic use. However, participants acknowledged the role of antibiotics to protect animal health and the integrity of the food supply chain. They debated the lack of a simple fix to antibiotics in the agri-food system and revealed preferences for preventive actions at farm level and supporting actions at market level. The study highlights the need to first tackle low levels of public understanding through effective risk communication including strategies such as targeted message framing and proactive, cross-sector OneHealth awareness campaigns, followed by the introduction of a trusted antibiotic use food labelling system.

Keywords: Antimicrobial resistance; Antibiotic use; Consumers; Labelling; Risk Perception; Risk Communication

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Introduction

Antimicrobial resistance (AMR) is a OneHealth challenge: over-use and mis-use of antimicrobials in both human and animal medicine, along with contamination of the environment, are primary drivers of AMR (ECDC 2022). As a 'whole of society' approach, OneHealth recognises the interconnectedness of the health of, and potential for disease transmission between, humans, animals, and the environment (World Health Organization 2015). As such, AMR needs to be addressed through a holistic OneHealth approach where inter-sectoral approaches are recommended which address risk points for increased AMR from both the human and animal health sectors (Innes et al. 2021; World Health Organization 2015). Within farming, there has been particular focus on prophylactic use of antibiotics with livestock, and treating animals with antibiotics of critical importance in human medicine (Higham et al. 2018; Magalhaes-Sant'Ana et al. 2017). European Union policy and regulation are driving changes to ensure prudent use of antimicrobials in farming. The European Commission (2020) has a 2030 target of reducing sales of antimicrobials for farmed animals and in aquaculture by 50%, and as of 2022, new regulations (European Union 2018a; 2018b) will restrict the use of veterinary medicinal products and medicated feed. This highlights the importance of behaviour change of actors across the agri-food system, particularly farmers, vets and food consumers. A large amount of research has explored behaviour change initiatives with farmers and vets (Golding, Ogden, & Higgins 2019; Innes et al. 2021; Reyher, Barrett, & Tisdall 2017). In contrast, only recently has academic attention turned to market-level interventions to bring about responsible antibiotic use, for example, through quality assurance schemes and food labelling (Bradford et al. 2022; Ritter et al. 2019). Limited research has explored the perceptions of consumers towards agricultural antibiotic practices and AMR (Barrett et al. 2021; Clark et al. 2017; Hudson et al. 2017). There is a need to ensure a common understanding of the OneHealth nature of AMR, and that the views and opinions of all of society are considered when ensuring collective actions are being taken to tackle this issue.

Communicating with consumers about antibiotic use in agriculture

Consumer studies on agricultural antibiotic use have largely emanated from the economics field, exploring market demand and consumers' willingness to purchase antibiotic-free meat and dairy products via front-of-pack (FOP) absence labels such as *antibiotic free* or *raised without antibiotics* (Bradford et al. 2022; Lusk, Norwood, & Pruitt 2006; McKendree et al. 2013; Wemette et al. 2021). Strategies to engage with consumers on the topic of agricultural antibiotic use have largely been confined to FOP labelling; however, the labelling strategy is

not without criticism, primarily with respect to the unintended impacts that may result from absence labelling (Abrams, Meyers, & Irani 2010; Barrett et al. 2021; Ritter et al. 2019; Singer et al. 2019). There are strong arguments for the development of a proactive risk communication strategy that moves beyond one-way approaches. Effective risk communication requires engagement with the public to understand their risk perceptions and tailoring approaches accordingly (Ancillotti et al. 2022; Jin et al. 2022). Survey research has indicated that consumer knowledge about the use of antibiotics in agriculture is low (Wemette et al. 2021). Several studies found that consumers have elevated levels of concern in particular about prophylactic (blanket) antibiotic use and antibiotic residues in food (Ancillotti et al. 2022; Barrett et al. 2021; Busch et al. 2020; Clark et al. 2017; Goddard, Hartmann, & Klink-Lehmann 2017). Whilst this research gives us an indication of the extent of public awareness and concern around given antibiotic practices, there have been no in-depth qualitative studies exploring public understanding and risk perception of antibiotic use in agriculture linked to AMR (Barrett et al. 2021).

Social representation theory: making unfamiliar risks familiar

Grounded in the discipline of social psychology, social representations theory is a framework that explains how a community makes sense of new or unfamiliar concepts (Moscovici 1984, 2000; Washer & Joffe 2006). Social representations are a useful theoretical tool used to explore public understanding of risks and to understand how people make sense of new threats (Joffe 2003). Risks are often communicated to people using a scientific risk assessment; for example, people may be advised of the probability and severity of a negative outcome following exposure to a threat. However, the public generally do not assess risks based on technical and objective information such as probability or cause and effect. Instead, their understanding is shaped by the symbols, metaphors, images and historical analogies which circulate in their everyday cultural and personal environment (Bartels & Reinders 2010; Joffe & Lee 2004). Social representations of risk allow people to cope and make sense of abstract or unfamiliar threats, thus making the unfamiliar familiar. When people encounter a novel risk, scientific knowledge is transformed into more accessible or understandable ways of thinking about the information via two sense-making processes: anchoring and objectification. As defined by Washer and Joffe (2006), "*an anchor reduces strange ideas to known categories and images, thereby setting them within a familiar context*". Anchors can serve to both raise or lower levels of concern associated with new information. Objectification is employed to make sense of an unknown object by linking it with more familiar and understandable images, symbols and

metaphors drawn from their past experiences and environment. The new threat is decontextualized, excess information removed, and certain elements are selected for interpretation through a lens of prior knowledge, experience and values (Ribeiro, Barone, & Behrens 2016). For example, a study exploring perceptions of the MRSA super-bug, a specific antibiotic-resistant bacteria, found that the public did not point to antibiotic overuse as a primary risk factor (Washer & Joffe 2006). Instead, they pointed to dirty hospitals neglected due to management culture and foreign hospital workers (a concept known as othering) – socially constructed concepts which were more familiar to them. When making sense of a new risk, it is common for a community to attribute blame for the risk to out-groups (Joffe & Lee 2004; Mayor et al. 2013). Joffe (2003) argues that peoples' understanding of a risk is strongly shaped by their social identity, and the automatic, often not conscious, protection of that identity.

Social representations help people make sense of new risk information in a way that protects their identity, maintain their values and beliefs, and minimises disruption to their everyday social practices (Rojas-Rivas et al. 2020). The values that a food consumer attaches to farming and food consumption likely will filter the way in which consumers interpret and make sense of new risk information about agricultural antibiotic use and AMR. Framing research reveals polarised perspectives on agricultural antibiotic use in social and mainstream media (Morris, Helliwell, & Raman 2016; Steede et al. 2019). Social representations of this issue are thus likely to be polemical - whereby the risk of antibiotic use in farming for AMR may be disputed and debated from many different angles, influenced significantly by different identities and values. However, it is largely unknown the representations that actually exist within consumers' minds, as there has been no in-depth study exploring consumers' perceptions and sense making of this risk to date. The current study aims to inform effective communication of the risks regarding antibiotic use and AMR in farming. Specific objectives of the study were:

i. Explore consumers' knowledge, awareness and risk perceptions of antibiotic use in agriculture and AMR.
ii. Identify social representations used by consumers to make sense of risk information on antibiotic use in agriculture and AMR.

Methods

Study context

The current study took place with consumers on the island of Ireland. A OneHealth approach underpins the AMR action plans of the Irish government, covering the Republic of Ireland (ROI) (Government of Ireland 2021) and the UK government, covering Northern Ireland (NI) (Department of Health and Social Care 2019). In 2020, out of 31 European countries, Ireland ranked 22nd highest and the UK 29th highest for antimicrobial use in animals, as measured by veterinary sales (European Medicines Agency 2021). In both countries, efforts have concentrated on changing practices related to the prophylactic use of antibiotics and critically important antibiotics (Department of Health and Social Care 2019; Government of Ireland 2021). In ROI and NI, while antibiotic use on farms is strictly regulated and comes under national quality assurance schemes, food producers do not have to communicate *specifically* to the consumer about antibiotic use on food labels. Globally, antibiotic-specific labelling has become popular as a market incentive (Ritter et al. 2019; Singer et al. 2019), and while this type of labelling is much less prevalent in ROI and NI marketplaces, recent industry-led initiatives have seen the emergence of food products which are advertised as "antibiotic free" or "raised without antibiotics" (Bradford et al. 2022). However, these products account for a very small proportion of produce available for purchase in ROI and NI.

Participants

The current study employed a qualitative research approach using focus groups. Purposive, convenience sampling was employed. Recruitment was aided by using household leaflet drops, posters in local shops, making contact with local clubs/community organisations, and through personal contacts. Inclusion criteria for all participants included: not coming from a farming background; being mainly responsible for food purchase and preparation in their household; and being regular meat and/or dairy eaters. Participants were selected to ensure an even spread across the following demographic factors: age, gender, geographic region (rural/urban), socio-economic status, dietary habits, and parents with young children. Participants were clustered into eight focus groups based on having similar demographic factors: (1) Urban Seniors (NI); (2) Rural Seniors (NI); (3) Young Urban Females (ROI); (4) Young Rural Males (ROI); (5) Low SES Urban Parents (ROI); (6) Rural Parents (ROI); (7) Urban Vegetarians (NI); and (8) Rural Foodies (ROI). Participants were clustered based on region (ROI/NI and rural/urban) to ensure no unnecessary travel burden was placed on participants. Thereafter, the clustering of participants based on similar demographics (including age, gender, dietary habit, parents) was used as it is a proven focus group technique that creates a more conversational setting in which participants feel at ease to open up and share their views and experiences (Morgan 1996). The

demographic factors used to select participants have previously identified as important for exploring food consumers' concern about antibiotic use (Barrett et al. 2021). Unlike survey research, which will sample participants in a representative manner so as to explore statistical differences between different groups, the aim with focus group research is not to explore group differences. Rather, the benefit of including these different demographic groups in a qualitative study is to ensure 'information rich' participants who are best suited to provide a diversity and range of insights to the questions under study.

Each focus group had between 3 and 6 participants ($n = 36$). Smaller focus groups have been recommended when the research aim requires a high level of participant engagement, as in the current focus groups which incorporated a risk information exposure exercise (Morgan 1996). The socio-demographic characteristics of the participants are shown in Table 1.

<<Table 1 about here>>

Procedure

Focus groups were carried out between September and November 2019. Each focus group was led by one of two trained facilitators. A note-taker was available for half of the groups. Upon arrival, participants were offered refreshments. After being asked to take seats around a table, participants were provided with an information sheet that explained the purpose of the study and the anonymous and confidential nature of their participation. The facilitator talked participants through the information sheet and noted ground rules such as not speaking over one another and treating other's opinions with respect. Participants were then asked to sign consent forms, if they were happy to participate. A short demographic survey was administered, and these sheets were immediately collected by the facilitator. All focus groups were audio-recorded. A pilot focus group took place with five mixed-age female participants living in a rural town in Ireland. Following the pilot focus group, questions were rephrased to assist participant understanding and question order was changed to improve the dynamic of the discussion.

The discussion group began with questions around participants' general perceptions of farming and food production and factors influencing their food purchasing and consumption decisions. Participants were questioned about their knowledge and personal experiences with antibiotics. Following this, a risk information exposure exercise was introduced whereby participants were presented with information about antimicrobials, antimicrobial resistance, and the role of antimicrobials in agriculture. In previous qualitative research carried out with

consumers, participants themselves acknowledged that they lack enough knowledge to make an accurate judgement on antibiotic use in agriculture (Cornejo et al. 2018). For that reason, a primary aim of the current study was to facilitate a study environment that made no assumptions about the existing knowledge of consumers and instead introduce them to the topic via explanatory information and capture their sense-making processes. Three principles guided the design of the information presented to the participants: (1) information was incremental, with blocks of information presented in 5 different steps, each step building on the knowledge from the previous step; (2) information was balanced, with different perspectives presented in a neutral, unbiased tone; and (3) information was evidence-based¸ developed from official sources and then further fact-checked by an inter-disciplinary team of scientists. The five information sheets (Appendix A) covered: (1) *What are antimicrobials?* (text); (2) *What are antimicrobials used for on farms?* (text); (3) *What are the risks of using antimicrobials?* (text)*;* (4) *Spread of antimicrobial resistance* (image + text); and (5) *What can be done about antimicrobial resistance in agriculture?* (text). The information sheets were presented to participants one at a time; the facilitator read the sheet aloud and then participants were given a few minutes to read it themselves before discussing the content as a group. The facilitator asked participants if the information they had read was new to them, and were then encouraged to freely discuss what they thought of the information in the sheet. No time limit was set for discussion following each sheet; participants were facilitated to discuss each information sheet at their own pace as a group. Following the last information sheet, the facilitator further prompted participants to think about the issue of agricultural antibiotic use from the farmer's perspective, and from the consumers' perspective and to give their views.

At the end of the focus group, the facilitator handed out debriefing sheets (Appendix B) with detailed information on animal welfare standards in Ireland/Northern Ireland, actions they as consumers could take to reduce the risk of AMR, and the addresses of official websites for further information. Participants were then thanked by the facilitator and each participant received a €50/£50 voucher to reimburse the time and travel costs they had incurred. Focus groups ranged between 90 – 120 minutes. After each focus group, the moderator completed a summary of the group discussion based on the notes taken during the focus group and their immediate impressions. Data collection was ended after the eighth focus group as all target key informant groups had been included and data saturation was reached with no new themes emerging.

Analytical approach

The audio recordings from each focus group were transcribed. An inductive thematic analysis was carried out following the guidelines of Braun & Clarke (2006). Two researchers independently listened to the audio-recordings and actively read through the transcripts, to immerse themselves in the data. Each of the researchers initially independently coded the data before coming together to discuss generated codes and deliberate over any differences in coding. In the next step, the lead researcher generated themes that were discussed and finalised amongst the research team, and then described and descriptive names were given to each theme. Finally, quotes were chosen to represent the themes.

Results

The focus group data were analysed and four themes formulated (Figure 1). Within each theme, social representations are identified that participants used to make sense of the risks of agricultural antibiotic use and AMR.

<< Insert Figure 1 about here >>

Antibiotics: use with caution

Some participants were unfamiliar with terminology in the information sheets such as 'antimicrobials' and 'antimicrobial resistance'. 'Antibiotics' was a term more comfortable for participants, and the term preferred throughout discussions. From the outset, some focus groups spontaneously introduced the concept that antibiotics are powerful drugs that need to be treated with caution and are associated with negative outcomes. Side effects of antibiotics were identified by participants with particular emphasis on the role they play in killing 'good bacteria' and weakening the immune system. Overall, there was strong awareness about misuse and overuse of antibiotics leading to resistance and loss of effectiveness. Awareness was mainly grounded in use of antibiotics in the human health setting. Doctor hesitation to prescribe antibiotics was the most common pathway for becoming aware about over-use and resistance, along with general news media and public awareness campaigns. From the outset of the focus groups, participants held a strong awareness of the role of antibiotics to treat bacterial infections specifically. A universal representation across the focus groups was the belief that antibiotics are a medicine used to *treat* an illness, taken when sick and the doctor has prescribed them to treat an illness. Participants frequently invoked language such as "fighting" bacteria, underscoring the idea of this medicine being used to attack and protect against illness: "*If you're sick, take them to get better…you have to be ill before you take them*" (P1, Young Urban Females, ROI). Medical doctors were described as gatekeepers of antibiotic use. Most associated antibiotic use as being strictly monitored by doctors who were increasingly hesitant to prescribe them, which in turn reinforces their belief that antibiotics are to be used with caution.

Most participants were unfamiliar with the practice of prophylactic ('blanket') use of antibiotics in farming, and when reading about it in Section 2 of the information provided, many seemed surprised by the information. This surprise was strongly anchored in the social representation that participants have of antibiotics as treatments, rather than preventives, coupled with their own experiences of seeing antibiotics being so tightly restricted in human medicine. The preventive use of antibiotics was not viewed as a normative behaviour in managing human health, and so participants struggled to make sense of this approach for managing animal health. These participants were strongly against what they understood to be preventive use of antibiotics in farming, citing concerns for the impact this would have on increasing spread of AMR.

"P1: they are given to them [animals] before they are even sick? Which is stupid. If you went to a doctors they wouldn't give it to ya until you were half dead. They won't give you an antibiotic until you actually have the signs of being sick.

P4: Yeah you have to beg for them. And they are being used to prevent infection that's not even there [pointing to sheet]." (Low SES Urban Parents, ROI)

However, there was division on the normativity of the prophylactic use of antibiotics; some participants made sense of the practice by anchoring it to their own experiences of vaccination and immunisation programmes, querying how the administration of antibiotics to prevent disease spread in farm animals would be any different. Mitigating their level of concern, some viewed the administration of medication to protect animals as a normative and standard behaviour in farming.

"P1: I didn't think they gave antibiotics to prevent an infection, that's overuse.

P3: But that makes good sense to me, because now we are getting flu injections to prevent the flu.

P1: But it's saying that the animal hasn't anything wrong with it, they are giving them the tablet to prevent, but sure it might never get the disease.

P5: But that's keeping them well….that's like the flu jab.

P1: That's like saying I think I'll take an antibiotic in case I get a sore throat next week. Sure you are overusing the antibiotic then, you might never get a sore throat. [P2 agrees].

P3: But I mean the flu injection, it's the same idea [P5 agrees]." (Rural Seniors, NI)

There was a strong preference for preventive actions in the form of good husbandry and good hygiene management on the farm to negate the spread of bacteria and AMR, reducing the need for antibiotics. As an alternative to prophylactic use, participants favoured preventive actions such as isolating sick animals from the herd, avoiding cramped or crowded housing conditions for the animals and regular vet visits. In particular, participants queried the role of vaccine programmes for animals to avoid the risk of animals getting sick and avoid the need for antibiotics. Anchoring to how pets are kept and how illness is dealt with in the human setting was visible here. Vaccination as an effective method of controlling disease spread was

familiar to participants through childhood vaccination programmes, yearly flu shots, or even vaccine programmes they use for their vets: "*What is it that's causing the infections? Can they not treat the cause rather than pumping them full off something to prevent...If they were kept in proper conditions maybe?"* (P2, Urban Seniors, NI)

AMR misconceptions

Although awareness of the threat of AMR was high, understanding of the mechanisms of how AMR spreads was limited. The idea that the more you take of something, the less effective it becomes made intuitive sense to people; however, participants in several of the groups held a 'person-centred' understanding of AMR, whereby they believed that *the person* becomes resistant or immune to antibiotics, not the bacteria:*"You get immune to it. If your body get immune to them then they won't work"* (P1, Low SES Urban Parents, ROI). With the exception of a few participants, most were previously unaware, or had not considered, the contribution of agricultural antibiotic use to AMR. This backdrop of general confusion and lack of understanding regarding AMR transmission set the scene for participants trying to understand AMR spread involving the agricultural setting, and for making sense of the explanatory graph presented in Information Section 4. There was significant confusion amongst participants about the mode of AMR transmission from agriculture to human. Taking the Low SES Urban Parents focus group as an example: at the beginning of the focus group, the belief amongst participants was that the person becomes immune to antibiotics by taking too many antibiotics and did not seem to understand the concept of transmission of resistant bacteria. When the graph was introduced, this group engaged in significant social learning, understanding that it was the AMR bacteria spreading (not antibiotics) and expressed surprise at its ability to spread - this conflicted with their belief that people became immune to the antibiotics:

> *"P4: It's strange, it's surprising to me that bacteria can be spread, like resistant bacteria. You'd think you have to build that up yourself, that it couldn't be spread…*
> *P3: You can get it through the food.*
> *P4: Yeah that's what I find strange like, you think you would have to keep taking antibiotics yourself for that to actually happen. You wouldn't think it could spread."* (Low SES Urban Parents, ROI)

Perhaps the strongest anchoring used by participants to make sense of AMR spread from farming to humans related to that of residual antibiotics. Many participants inferred the spread of AMR through human ingestion of antibiotics on meat or dairy products: "*We eat*

everything that the animals ate" (Young Rural Males, ROI). In some cases, group discussion prompted clarification of this point. When others in the group corrected or challenged fellow participants, there was a weakening of the belief. However, in some groups, that assertion went uncontested. Even in the presence of the diagram, which clearly outlined the transfer of resistant bacteria as the root of the problem, some participants still inferred that the main causeway for AMR transmission was through humans consuming antibiotics in meat and dairy products. The 'human-centred' transmission belief (i.e. human consumption of antibiotics leads people to become immune) may further reinforce the belief that residual antibiotics on products is the pathway for AMR transfer. This was an area of confusion and concern for many.

> *"P3: How far do they last along the food chain, are they [antibiotics] still in their system when it reaches us?*
> *P2: How long can an animal be slaughtered after getting antibiotics before it reaches us? Is there a period where the antibiotics can leave their system or are we in danger, what's the protocol there?*
> *P3: Like there's worries around resistance to antibiotics as it is. So if you are taking antibiotics through your food…that's really worrying, that would really make you stop eating meat altogether if that's the case."* (Young Urban Females, ROI)

This belief gave rise to consumer concerns and more reactionary responses, including consumers reflecting whether they should stop eating meat altogether. Some participants anchored this discussion in the wider conversation about human diet and disease, making connections between consuming unknown substances within food products and the increase in health problems such as cancer and allergies. This concern was linked with having little control or power to know how food is produced. *"There is a saying isn't there, we all talk and we all hear about all these people being sick and we always say "ah it's something we are eating".* (P5, Rural Seniors, NI). Participants queried what rules and regulations are in place to ensure that produce coming to market contains no trace of antibiotics. Only a few participants were aware of the withdrawal period regulations in place for the provision of antibiotics prior to produce entering the supply chain.

Thinking about bacteria becoming stronger (rather than resistant) made intuitive sense to participants: "*Well all the talk now is how we are over-using and <u>germs are getting stronger</u>*" (P2, Urban Seniors, NI). A theme that arose all focus groups was the concept that 'bad germs' can be killed with 'good hygiene'. Situating the conversation within these terms appeared to allow participants to make the most sense of OneHealth AMR transmission. Participants were

familiar with and understood the concept of protecting against germs in the kitchen setting, and used this as an anchor to understand how resistant bacteria may spread and contribute to the problem of AMR. For example, participants discussed the concept that with good kitchen hygiene, 'bad germs' on food can be killed and the personal risk somewhat eliminated. Participants viewed bacteria as a feature of daily life and they discussed how germs spread in many different settings (e.g. in school settings, hospitals), not just in agricultural and food settings. Hygiene is viewed as a personal practice and as such, a risk mitigation strategy that everyone can undertake. Participants felt AMR spread was an issue of collective responsibility across both human and animal settings. Participants discussed the importance of hand-washing, use of hand sanitiser, good cleaning practices, storing and cooking food properly, and good hygiene etiquette when sick as actions that all individuals can take to prevent the spread of bacteria, and thus the spread of AMR.

Farmers' roles and responsibilities

The motivations driving farmers' antibiotic and animal health practices were widely debated within focus groups. Some participants had a positive social representation of farming in Ireland and Northern Ireland. Farmers were viewed as 'care-givers' and custodians of animals. Participants felt that antibiotics were being used with the best interests of the animal's health in mind: "*The farmer is the main carer for the animal and wants the best for the animal. It's not as cut-throat as it might seem. For a lot of farmers, this may be more humane."* (P2, Rural Parents, ROI). They acknowledged that infection is commonplace and therefore it is easier and safer to treat all animals in a big herd to prevent disease spreading and that simply cutting out or suddenly reducing antibiotic use on farms was not a simple fix. To ask farmers to change practices that are so institutionalised and relied upon was viewed by many participants as a challenging ask and some participants felt empathy for the farmers. Participants discussed the challenge for farmers to implement such changes including making changes to their infrastructure, the monetary and time investment that would be involved, and the associated concern over potential loss of animals due to ill health, and therefore loss of income for the farmer. Rather than calling for top-down regulation in the form of penalties/taxes/fines to regulate antibiotic use, most participants highlighted the need for government to support farmers to make proactive changes through incentive schemes or grants.

> *P4: They are good solutions but they are a lot of hassle for farmers and will cost more money.*

P1: the cost is too high…there is too much pressure on the farmer to do all of this. You could be the best farmer out there, you could love your animals and be looking after them. But if you don't have the money to do it…

P2: or the help.

P3: You see where it is saying about only treating the sick animals, but by the time they realize the animal is sick they might have spread it to the rest. That solution is not good. You'd have to keep testing and checking them. Sure, that would take up so much time." (Urban Parents, ROI)

Other participants held a more distrustful social representation of farming. Farmers were viewed as profit-driven business people, motivated mainly by money. Participants questioned whether it was a cost-saving exercise for farmers to give antibiotics to their animals to prevent illness spreading in a farm. Some participants felt that a profit-driven farming sector was to blame for improper antibiotic use on farms. In particular, larger, more intensive farms were associated with a profit mentality. Some participants believe that improper antibiotic use would be less of an issue on organic farms, and on Irish/Northern Irish farms that were generally associated with smaller, family establishments.

"P2: The smaller scale farmer looks after the animals really well, they are their life but with the larger scale, you wonder is there a totally different operation going on? [Others agree]. The bigger farmers are more money driven.

P1: The smaller farmer would be more clued in and conscious. Whereas if it's mass production, it's not really a farmer – it's a load of people working for a certain amount of money. They are not going to put in as much thought or they are not going to be as concerned about the consumer." (Young Urban Females, ROI)

Participants engaged in a nuanced and collective weighing up of the risks and benefits of administering antibiotics to animals in the context of the food production system. Participants discussed the role that antibiotics play in farm management and in maintaining the integrity of the food supply chain, and considered the consequences of a change or removal of antibiotics in farming for the food supply chain and the quality of food products. Some participants discussed the fact that antibiotics allow farmers to run a viable farm, and that the impact of removing antibiotics would be drastic on farmers. However, of most concern to participants

was the need to prevent "*diseased food products*" from entering supermarket shelves and the impact this could have on human health; some positioned antibiotics as "*the lesser of two evils…I'd be more worried if they didn't use it."* (P3, Rural Parents, ROI). There was concern about the consequences for animal health if antibiotics were removed entirely from farms. While some were concerned from an animal welfare perspective, for the most part, these concerns related to the thought of sick animals entering the food chain and the impact this would have on human health: "*We are eating the infection"* (P1, Urban Young Females, ROI). Some participants drew on previous infectious disease outbreaks, such as the "foot and mouth disease" and the "mad cow disease" (bovine spongiform encephalopathy outbreak), to make sense of the role of antibiotics in preventing ill animals in the supply chain. Participants were willing to accept a certain level of antibiotic use in farming in order to prevent sickness of animals and maintain integrity of the supply chain but this was dependent on the proper checks being in place, as well as taking preventive action to avoid over-use of antibiotics (e.g. avoiding preventative use, using alternatives, reducing consumption, improving herd health).

Consumer control strategies

The fact that participants did not know specifically how antibiotics were being used on farms, and had little previous knowledge about the OneHealth aspects of AMR was itself a source of concern. Some of the participants felt they are oblivious to what is going on behind the farm gate. The lack of transparency itself was a cause for concern: "*There is kind of an ignorance on us as a consumer about this, a lack of information. I think the fact that we had absolutely no knowledge is kind of frightening.*" (P3, Young Urban Females, ROI). Loss of control and power in their role in the food chain and a belief that as consumers, they are always at the mercy of others (farmers, factories, regulators, retailers) drove concern. Participants perceived that they had to blindly trust others and that there was little that they could do as consumers to protect themselves or take action against potentially harmful consequences of over-use of antibiotics in food production. Participants were also concerned because they did not know what standards or regulations were in place to govern the use of antibiotics in food production, and therefore they felt they had no process in which they could trust and find reassurance. The issue overall left many of the participants feeling in a vulnerable position as consumers.

Participants believed that consumers should be more aware of the use of antibiotics in farming, although cautioned the need for balanced and unbiased information provision. Participants discussed how once aware and motivated, consumers could be part of the solution and help bring about change. In doing so, participants queried their own blame in supporting a

system that produced cheap produce at the loss of good animal health and welfare standards, thus propping up a farming system that was reliant on over-use of antibiotics. Participants discussed how individual purchasing practices and decision-making of consumers are as much to blame, as the behaviours of others in the system (e.g. farmers): "*I do feel there is too much over-production. If we all made better decisions as consumers then there might be less of a need to do this."* (P1, Rural Parents ROI).

Different consumer actions were suggested, including: reducing meat and dairy consumption; switching to purchasing organic food; and paying more for produce from farms they know have made efforts to eliminate or reduce antibiotic usage. Participants anchored a move to more plant-based diets to wider system change needed to combat other issues such as environmental problems and climate change. Participants also spoke about the need to switch to – and pay for – better quality meat produce. Some participants felt strongly about changing their own behaviour and indicated that they would personally be willing to buy produce that was labelled as antibiotic-free or reduced-antibiotic use, and that they would be willing to spend more on such products, although simultaneously acknowledged that increased cost could be a barrier for other consumers.

> "*P5: If there was a package of meat sitting in front of me on the counter and it had a label on it that the animal did not have antibiotics, I would buy that. I don't care how much it would cost, I would buy that. [Others agree]."* (Rural Seniors, NI)

Participants indicated that behaviour change on the consumers' part was conditional on the appropriate governance and regulatory processes being in place. The role of trusted and verifiable labelling and branding for consumers to distinguish between higher quality products was viewed as important. In particular, it was highlighted that consumers would have to be able to trust regulation and labelling; here the role of checks and monitoring was particularly important for participants. Participants also indicated that farmers, and not just processors or retailers, would need to feel the impact and monetary return of the consumer shift, to ensure that there was motivation amongst farmers for changing their practices.

Discussion

The current study offers an insight into consumer understanding of agricultural antibiotic use and AMR. When exposed to risk information on the topic, participants exhibited low existing awareness and grappled to understand transmission concepts. Participants used different social representations to make sense of this new risk information (Joffe 2003). These social

representations provide insight into how consumers formed risk perceptions and opinions on the actions they would like to see taken to address AMR in the agri-food sector. A number of recurrent thematic narratives emerged throughout the focus group discussions, which tell us about the "key stored elements of the social representations" (Joffe & Lee 2004) that consumers hold about antibiotics, about farming and food systems, and the implications this has for how they view antibiotic use in farming. For example, participants used anchoring to express their views about antibiotics in human medicine and believed that they need to be used with caution, and for treatment, not prevention. These social representations clearly then shaped participants' preferences for reduced use of antibiotics in farming, and in particular, reduced prophylactic use. In another instance of sense-making, participants engaged in objectification to understand who was responsible for improving antibiotic use practices in farms - they evoked wider on-going debates about intensification of the farming sector and the changing role of consumers in the food system (responsible consumerism). These social representations then influenced different views amongst participants about the power of farmers and consumers to initiate change in how antibiotics are used within agriculture. Analysing the focus group discussions through the lens of social representations enabled a more nuanced understanding of how people respond to new risk information – reinforcing that scientific risk information alone is not used to understand new threats (Bartels & Reinders 2010; Joffe & Lee 2004). Instead, consumers will interpret information on antibiotic use in farming through an existing lens of their own consumer identity, values and knowledge. The implications of this for risk communication strategies are that we must not expect consumers to respond to information uniformly; and we must be prepared to engage in multiple communication efforts that target and leverage the values and belief systems of different consumer groups.

Research consistently finds low understanding of AMR, with misconceptions about transmission a common occurrence (Bradford et al. 2022). The current findings correlate with research that indicates the public largely tend to view antibiotic use within a human health lens, as opposed to associating their use to agricultural settings (Wemette et al. 2021). Misconceptions and confusion are thus a feature of how consumers respond to information about the contribution of agricultural antibiotic use to AMR. As has been previously found in studies of AMR in human health settings (Redfern et al. 2018), the current study reinforces that AMR terminology is problematic; resistance is not an intuitive term in contrast to concepts such as "bad bacteria" and "dirty germs". Problematic terminology as well as misconceptions about resistance spread translates to further difficulty in understanding AMR as a OneHealth issue (Innes et al. 2021). It is imperative to address such knowledge gaps and misconceptions,

particularly as it has been shown that consumers are increasingly being exposed to polemical information on this issue dominated by special interest groups through mainstream and social media (Morris et al. 2016; Steede et al. 2019). The need for proactive and effective risk communication with the public on the topic is crucial, to avoid reactionary responses or unintended impacts. Importantly, consumers need to have a thorough understanding of agricultural antibiotic use prior to the widespread rollout of any specific antibiotic-use labelling (Ancillotti et al. 2022; Bradford et al. 2022). Strategies that can help to address knowledge gaps, target misconceptions, and improve understanding include careful message framing of AMR and OneHealth (Wellcome 2019); educational interventions (Ancillotti et al. 2022); cross-sector, OneHealth public awareness campaigns (British Veterinary Association 2019); public engagement initiatives (Redfern et al. 2018); and bottom-up movements (Ancillotti et al. 2022). A deficit model, top-down approach to educating consumers about agricultural antibiotic use and AMR is unlikely to be effective (Barrett et al. 2021). Previous research has indicated that sizeable consumer segments tend to wilfully ignore or avoid AMR information related to agriculture (Meerza et al. 2021). Instead, careful development and framing of communication-based campaigns is required which will be cognisant of the values and beliefs of the message recipient. Key to the success of any of these initiatives is to directly leverage and/or target the social representations held by consumers, including those uncovered in the current study. For example, in the current study, participants situated their discussion of antibiotics within value-driven frames related to farming intensification, responsible consumerism and collective action. Future initiatives could explore the value of contextualising communications about agricultural antibiotic use within similar frames.

Previous research based on mainstream and social media content raised concerns that public debates on antibiotic use and AMR would likely be polarising (Morris et al. 2016; Steede et al. 2019). However, when given balanced and evidence-based information, the space to discuss, and a group context to hear others' thoughts, participants in the current study debated agricultural antibiotic use and farming practices in a relatively deliberative and reflective manner. In the current study, there was limited engagement in the 'othering' that is often a feature of sense making related to infectious disease risks (Washer & Joffe 2006). There was some evidence of participants pinpointing larger, intensified farmers as the primary culprit for agricultural-related AMR spread, which correlates with previous research (Barrett et al. 2021). Factory farming as a social representation typically conjures negative imagery for consumers (Redding, Parsons, & Bender 2021) and is viewed to conflict with the rural idyll that the public associate with farming (Short 2006). However, many participants in the focus groups were

reflective in their critique of farm practices and farmers; many indicated that they were empathetic towards the situation of farmers – citing difficulties to making seismic changes to husbandry practices on farms to reduce reliance on antibiotics. This could be a particular reflection of the geographical context of the current study, given that consumers tend to associate livestock farming in Ireland with small, pasture-based family-farms (Regan & Kenny 2022). Future research should consider cross-cultural differences in social representations of antibiotics and farming, particularly considering aspects of identity and blame attribution.

To inform targeted risk communication campaigns, future research should specifically identify the information needed by different consumers segments, along with preferred information sources and communication channels. Targeting knowledge gaps can improve understanding, motivate consumer action, and ensure informed choice but this must be matched by availability and accessibility of viable alternatives for consumers at market level. In the current study, participants discussed the actions needed at different levels to reduce reliance on antibiotics within the food system. Participants initiated discussions around responsibility as a way to localise the source of the AMR problem and help to establish a sense of control over the risk (Joffe & Lee 2004; Mayor et al. 2013). Participants discussed the role of responsible consumerism within the food system to initiate change including actions such as reducing animal-based diets; buying organic alternatives; and paying more for produce from higher animal health and welfare systems. Food labelling is gaining momentum as a market level intervention, including responsible antibiotic use logos (Ritter 2021), antibiotic footprints (Ancillotti et al. 2022), or absence labelling (e.g. raised without antibiotics) (Bradford et al. 2022). As with other agricultural technologies, such as the use of GMOs and hormones (Costanigro & Lusk 2014; Sunstein 2021), labels serve as key signalling devices for consumers, allowing them to infer aspects of food production otherwise invisible to them in their typical food decision-making contexts of shops and restaurants (Abrams et al. 2010; Barrett et al. 2021). Consumers likely hold very specific social representations to interpret and infer different antibiotic-use food labels and the development of future labelling strategies should be cognisant of the existing knowledge and beliefs that consumers will use when exposed to new labels. In order to be successful, any future antibiotic use labelling initiatives will need to be transparent and trusted, underpinned by a verifiable monitoring system, with use of FOP labels that are clearly understood by their intended consumer audiences. The focus group design allowed participants to co-construct meanings and engage in deliberation, allowing for a rich insight into their sense-making processes. However, given the qualitative design of the current study, it is not possible to make any remarks on the likelihood of behaviour change by different

consumer segments in the general population. Future research should aim to triangulate the current findings through investigations that could identify specific consumer trends and quantify levels of awareness, knowledge, risk perceptions and attitudes held by the wider general population. In particular, research should explore the sense making processes of consumers when exposed to different types of antibiotic specific FOP labelling on food products and likely impacts on intended consumer behaviour change.

Compliance with ethical standards

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Table 1: Characteristics of participants in the 8 focus groups and overall sample (*n* = 36)

Socio-demographics	**Focus Groups**								
	1 (*n = 6*)	2 (*n = 5*)	3 (*n = 4*)	4 (*n = 4*)	5 (*n = 5*)	6 (*n = 4*)	7 (*n = 5*)	8 (*n = 3*)	Total **(*n = 36*)**
Gender									
Male	0	0	0	4	0	1	2	2	**9**
Female	6	5	4	0	5	3	3	1	**27**
Age									
18-35	0	0	4	4	5	0	4	0	**17**
36-55	0	1	0	0	0	4	1	3	**9**
56+	6	4	0	0	0	0	0	0	**10**
Children									
<12 years of age	0	0	0	0	5	4	2	2	**13**
None />12 years	6	5	4	4	0	0	3	1	**23**
Education level[a]									
Secondary	1	2	0	0	5	0	0	1	**9**
Graduate	3	0	1	2	0	4	1	0	**11**
Post-graduate	2	1	3	2	0	0	4	2	**14**
Personal income[b]									
< €25,000	3	5	0	0	5	2	3	0	**18**
€25,000-50,000	2	0	4	3	0	1	1	2	**13**
> €50,000	0	0	0	1	0	1	1	1	**4**
Pet ownership									
Yes	5	4	1	1	4	3	3	2	**23**
No	1	1	3	3	1	1	2	1	**13**
Farm Visits									
Regular access	2	0	4	2	0	0	0	0	**8**
Visited in the past	4	4	0	2	2	4	4	3	**23**
Never been	0	1	0	0	3	0	1	0	**5**

Focus Groups: 1. Urban Seniors (NI); 2. Rural Seniors (NI); 3. Young Urban Females (ROI); 4. Young Rural Males (ROI); 5. Low SES Urban Parents (ROI); 6. Rural Parents (ROI); 7. Urban Vegetarians (NI); 8. Rural Foodies (ROI).

[a] Missing responses for 2 participants; [b] Missing responses for 1 participant.

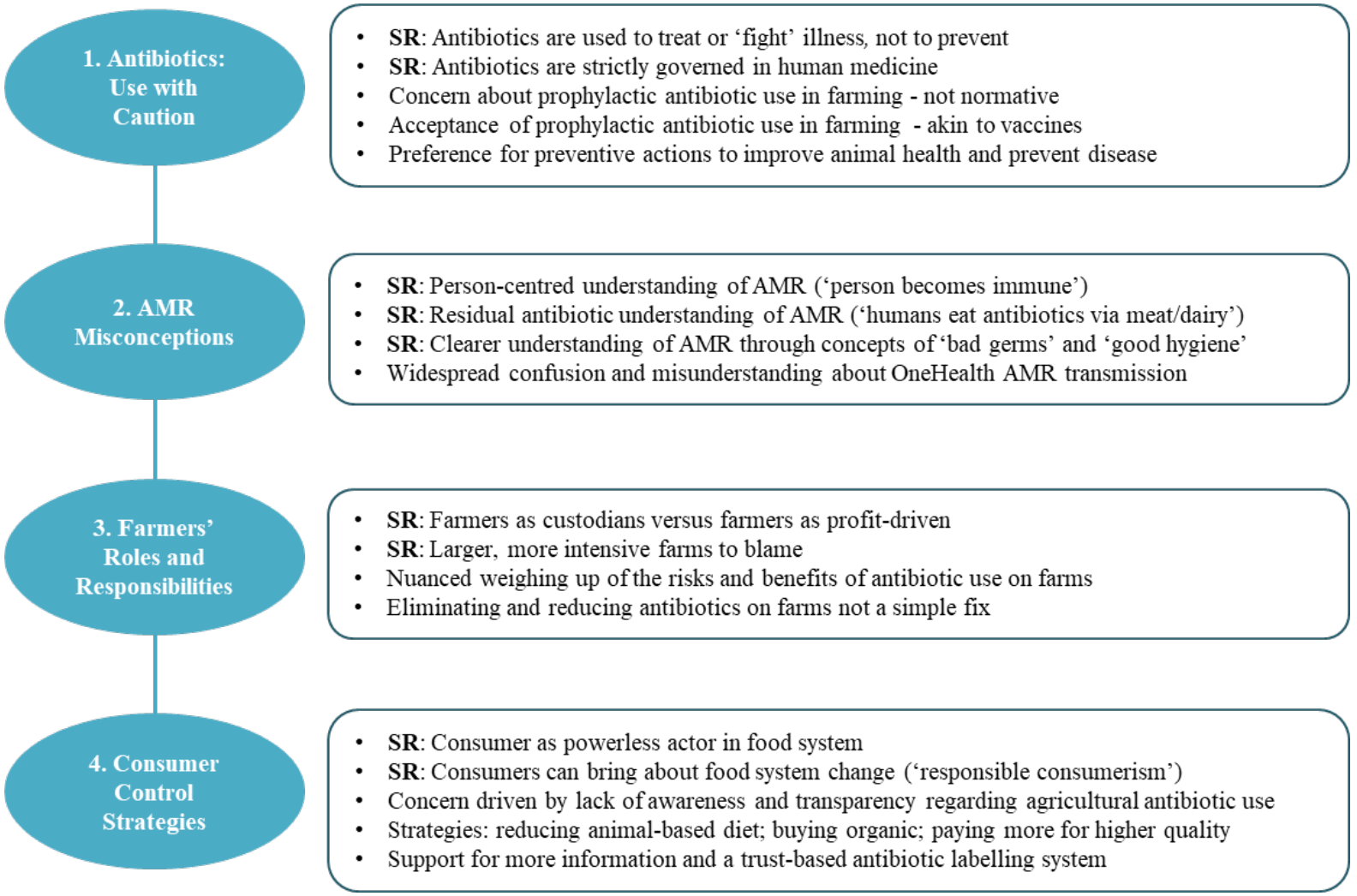

Figure 1: Thematic map of consumers' social representations (SR), risk perceptions, and sense-making of agricultural antibiotic use and antimicrobial resistance (AMR) based on a qualitative focus group study with consumers on the island of Ireland (n = 36)