Citizen Science for Food Standards Challenges: Programme Review

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Summary

Background

Citizen science is an umbrella term that describes a variety of ways in which members of the public can participate in science. The main characteristics of the approach are that:

1. citizens are actively involved in research, in partnership or collaboration with scientists or professionals; and
2. there is a genuine outcome, such as new scientific knowledge, conservation action or policy change.

Citizen science involves communities participating in data collection or analysis, or other kinds of collaboration, like co-creating research questions and interpreting data. The approach, endorsed by the European Commission for Research, Science and Innovation, allows the communities we serve to be involved in building the evidence-base on which policy decisions are made, and offers wider benefits to participants (such as expanding scientific knowledge). Citizen science can open up engagement with communities who are underrepresented in research.

The FSA's programme of citizen science work builds on collaboration between UK Research and Innovation (UKRI), the FSA and Food Standards Scotland, to develop a joined-up approach to tackle the challenges of maintaining safe food in the UK. Key recommendations of this collaboration were to invest in public engagement and citizen science (aligning with UKRI's commitment to citizen science and participatory research, as outlined in its vision (2010 – 2022)), and to build and strengthen partnerships across the food safety research and innovation community. To inform these aims, the 2021 FSA review 'Citizen Science and Food' explored how citizen science methods have previously been applied to FSA research priorities. The review identified a growing body of research and recommended further investment in this area to build capacity and capability, and spread the use of these methods among the food science community. Subsequently, in 2022 the FSA and UKRI (footnote 1) launched the Citizen Science for Food Standards Challenges funding call, for projects that would use citizen science methods to address the FSA's areas of research interest (ARIs).

The aims of the call were to:

1. assess the utility of the citizen science approach in exploring food standards challenges.
2. facilitate the use of citizen science methods, and build capability, in the food policy research community.
3. expand the range of people from outside of academia involved in food policy research.

4. provide learning opportunities to the members of the public involved as citizen scientists.

Six projects were awarded funding, each addressing an ARI, exploring topics such as antimicrobial resistance, food hypersensitivity, consumer practices and food safety, and novel plant breeding methods. All projects used citizen science methods to help researchers gather rich information in certain settings or communities.

Across the programme, the six projects facilitated collaboration between: 600 citizen scientists, nine universities, 12 partner organisations, four community or specialist advisors and two business representative bodies. These collaborations brought multiple benefits to researchers', citizen scientists and to the partner organisations, advisors and stakeholders. This report details these, along with key findings from each project, and operational learnings from the programme to inform future work using citizen science methodology.

This report outlines preliminary findings from each of the projects and considers the success of the programme overall. Detailed findings from each project will be published in the form of project reports on the FSA website, in sequence with publications in scientific journals.

Project Summaries

The projects awarded funding under the call were:

Engaging food hypersensitive communities in citizen science led by Prof. Julie Barnett of University of Bath. Food hypersensitive (FHS) citizen scientists, researchers, and partner charities investigated the eating out experiences of FHS consumers. Findings highlight the importance of the planning process when preparing to eat out, and the significance of digital information provision in cafés and restaurants.

Exploring the chopping board microbiome co-led by Dr Alan Goddard of Aston University and Dr Rachel Pateman of University of York. Student citizen scientists and their households collaborated with researchers to investigate the kinds of bacteria on their home chopping boards, by swabbing the boards and participating in laboratory testing. Findings suggest that cleaning behaviours were influenced by which foods made contact with the chopping board, and that chopping boards were often not adequately cleaned.

Citizen science and antimicrobial resistance (AMR) led by Dr Sarah West of University of York. Citizen scientists, and organisations representing grower communities, collaborated with researchers to test home grown salad for bacteria, and to find out if these bacteria were antimicrobial resistant. Citizen scientists and researchers found target bacteria with antimicrobial resistance on homegrown salad leaves, suggesting that more research is needed to determine pathways of AMR transmission.

Using citizen science to explore plant breeding and investigate food-chain transparency for novel breeding methods led by Dr Gulbanu Kaptan of University of Leeds. Citizen scientists collaborated with researchers to investigate knowledge and attitudes about plant breeding methods, including novel methods like gene editing.

Citizen scientists and researchers discovered that they could develop materials and learning exercises that increased peoples' understanding of methods of plant breeding (including novel methods) that may be needed for developing policies.

Food allergy awareness champions: Towards improving food safety standards in online food procurement for people with food hypersensitivity led by Dr Tassos Koidis of Queens University Belfast. FHS citizen scientists, researchers and partner allergy charities and experts, investigated FHS consumers experiences of ordering takeaway food online and whether a selection of procured meals were allergen free.

Citizen scientists and researchers discovered that procuring and testing meals for allergens was a complex process. The study generated insights on the barriers and perceptions of procuring food online for FHS consumers, particularly on the influence of age in risk perception and key issues around the effectiveness of labelling in online food outlets.

Finding the right formula – establishing the feasibility of doing science in the home to assess the safety of Powdered Infant Formula preparation led by Dr Aimee Grant of Swansea University. Citizen scientists, researchers and collaborating NHS and charity partners developed research plans and methods for parents and carers to monitor the process of preparing powdered infant formula. Findings suggest that the safe preparation of formula milk was, in some cases, hindered by the poor performance of water heating equipment.

Programme findings

All the projects were able to successfully test their methods and explore research questions, confirming the feasibility of adopting citizen science methods to explore food safety challenges. The insights generated from these projects will help to inform the methodology of any larger follow-on studies. Some findings also have the potential to inform policy and have provided evidence that would have been challenging to investigate without the use of a citizen science approach.
Projects gathered feedback through various mechanisms such as surveys, focus groups and interviews. Citizen scientists reported a variety of benefits from their participation including:

- increasing their knowledge and understanding of the research areas investigated.
- becoming more informed about scientific methods.
- gaining experience in study design, practical data collection methods, data analysis and interpretation.
- developing insight by interacting with one another and reflecting on their own practices and those of others.
- feeling they had a made a valuable contribution to a research area of importance to them.

Researchers and partner organisations also benefitted from the citizen science approach. Through working with partners (e.g. organisations like charities and community groups), the projects benefited by having key subject knowledge early in the research planning process. The partner organisations benefited by getting new perspectives on working with members of the public using citizen science methods and gaining new insights into the views of the community in the areas researched. They also gained rapid access to research findings that could be presented in ways most useful to them.

Across the programme as a whole, we identified key issues that should be considered when designing a programme of funding for citizen science projects, including:

- provide sufficient time to allow for recruitment of citizen scientists. Links with relevant community group or charities, and using social media channels, can be advantageous.
- to help citizen scientists stay engaged with the project provide regular communications, events and/or activities, and ensure this is reflected in project planning.
- given the co-created nature of citizen projects, it is helpful to adopt an iterative approach to ethical approval.

Conclusion

This programme of work successfully met its four primary aims (as per below) and additionally generated a number of useful insights to inform the design of future citizen science projects.

1. Facilitate the use of citizen science methods and build capability in the research community. Three programme meetings were held to enable projects to build networks and

share learnings. Additionally, UKRI and the FSA co-hosted a Citizen Science for Policy and Practice conference. With international speakers and a variety of projects showcased, the event was popular reaching over 200 attendees.
2. Assess the utility of citizen science approaches in exploring food standards challenges. The six projects used citizen science approaches to explore various food standards challenges, across four different FSA ARIs. Whilst several operational learnings have been noted, the programme has demonstrated the merit of these approaches in terms of providing access to the various domains that consumers eat and prepare food in.
3. Expand the range of people from outside of academia involved in food policy research. In addition to the cohort of researchers from nine universities, projects in the programme collaborated with over 600 citizen scientists and the projects worked with 12 partner organisations, four community/specialist advisors and two business representative bodies. These collaborations brought multiple benefits to researchers', citizen scientists and partner organisations, as well as adding to the richness of the knowledge generated in each of the projects.
4. Provide learning opportunities to members of the public involved as citizen scientists. Feedback from citizen scientists suggests a range of learning outcomes from their participation in the funded projects, from topic knowledge (in areas such as novel plant breeding and microbiology) to a better understanding of scientific processes (such as research design and data analysis).

Background

Biotechnology and Biological Sciences Research Council (BBSRC), Economic and Social Research Council (ESRC), FSA, and Food Standards Scotland work collaboratively to coordinate research to help tackle the challenges of maintaining safe food in the UK. The partners held a shared strategic workshop in 2020 that determined a key element of their joined-up approach; to invest in public engagement and citizen science.

UKRI has a long-term commitment to citizen science and other kinds of participatory research. The FSA is also keen to utilise participatory research and in 2021 published Citizen Science and Food: A Review. The review explored how citizen science methods have been applied to FSA's Areas of Research Interest (ARI, see Annex 1). The review identified a growing use of citizen science methods in research relevant to food safety and recommended further investment to build capacity and capability.

In line with the review's recommendations, UKRI and FSA launched a joint funding call: Citizen Science for Food Standards Challenges. Six pilot research projects were awarded funding to utilise citizen science methods to explore one or more of the FSA's ARIs. The specific aims of the call were to:

1. Facilitate the use of citizen science methods, and build capability, in the policy research community.
2. Assess the utility of the citizen science approach in exploring FSA research priorities.
3. Expand the range of people from outside of academia involved in research related to food systems challenges.
4. Provide learning opportunities to the members of the public involved as citizen scientists.

Citizen science methodology

'Citizen science' is any research where citizens, not usually professional scientists, wholly or partly develop and deliver research projects. Whilst there is no one size fits all definition, it involves communities participating in data collection or analysis, or other kinds of collaboration, like co-creating research questions and interpreting data. The method is endorsed by the European Commission for Research, Science and Innovation as a method well suited for policy

issues and is a key part of their Science with and for Society work programme (SWAFS 2020). It is a unique approach that can allow access to settings and communities that would be difficult to achieve using other methods. Citizen science can help achieve innovative and ambitious research aims, such as:

- extensive or large volume data collection
- crowd sourcing analysis
- community engagement and involvement,
- science education
- gaining deeper understanding of social or cultural context
- gaining deeper understanding of complex practices and/or private domains

Citizen science methods are frequently associated with projects where citizens collect or analyse data for 'large' studies, particularly where data is collected over long time periods, wide geographies or where there is a high volume of data to be analysed. However, use of citizen science methods is not limited to facilitating large scale collection and analysis. Citizen scientists can take on a variety of roles in research projects, contributing to the development of research priorities, research questions, and research protocols. Although citizen scientists are predominately not formally trained, some projects may involve citizens with professional training in scientific methods.

The European Citizen Science Association (ECSA) reports that practices within citizen science are broad and evolving, but that there are 10 key principles to underlying good practise and successful uses of the approach. All projects in the Citizen Science for Food Standards Challenges Funding Call were planned and carried out in line with these principles.

Throughout this report the term researcher(s) refers to professional researchers and citizen scientist(s) refers to members of the public who take on researcher roles and tasks.

Citizen science and the food system

Food safety practices are complex and found across production, processing, retailing, food service in public spaces and in people's homes. Through working with groups and individuals within all of those spaces where food is handled, there is the potential for richer information to be captured than would otherwise be possible. Citizen science can allow novel research in areas in which consumer and food business operator behaviour and perception play a key role in ensuring food safety and standards. In some settings the approach may be essential. For example, understanding food safety in private domains, like the home environment, would be difficult to research without collaborating with citizens. The 2021 FSA review 'Citizen Science and Food' explored how citizen science methods have been applied to FSA research priorities. The review identified a growing body of research and concluded that citizen science approaches have the potential to help investigate and better understand complexity in the food system and thereby inform nuanced policy.

Programme design

The 'Citizen Science for Food Standards Challenges' funding call required projects to 'be a collaboration between researchers, a specific group of citizens and, where appropriate, relevant partners from outside academia' and for citizens and partners to be involved in co-creating the projects.

For projects to be eligible for the funding call they had to:

1. contribute to addressing at least one of the FSA ARIs.
2. sit within the remit of BBSRC and/or the remit of ESRC
3. have a clear justification and aims for using citizen science methods

4. involve a defined group, or groups, of people in the UK, in co-developing the project from the beginning, expanding engagement outside academia with FSA ARI themes
5. adhere to best practice in citizen science, as outlined in the ten principles of citizen science and the ECSA characteristics of citizen science where possible.
6. demonstrate a commitment to the principles of equality, diversity and inclusion in both the project design and delivery team.

An independent funding panel was administered by FSA and UKRI (through BBSRC) that reviewed applications and recommended awarding funding to six pilot projects. UKRI and FSA provided support and guidance throughout the lifetime of each project, including mentoring through a learning partner. This support included regular check-in meetings between the learning partner and the researcher in each project. Projects were also supported by an FSA liaison, involved in research in the ARI that the project related to. The FSA liaison was in regular contact with project leads and provided links to FSA policy and communication teams colleagues, and other government agencies or departments, where appropriate.

There were three facilitated programme meetings, where researchers could discuss ongoing progress or issues, share lessons learned and take part in workshop discussions. Additionally, researchers also attended ae 'Citizen Science for Policy and Practice' conference. This conference, hosted by UKRI and FSA in partnership with the Institute for Community Studies, was held in October 2022 and was open to anyone with an interest in citizen science. The event supported attended to learn more about what citizen science is, and what opportunities it offers for policymakers, funders and researchers. With international speakers and a variety of citizen science projects showcased (including the six funded projects), the event provided networking opportunities and workshop discussions on a variety of subjects, such as ethical working and valuing citizen scientists. The event was well attended with over 200 attendees.

The Projects

Engaging food hypersensitive communities in citizen science

Prof Julie Barnett, University of Bath

This pilot study sought to explore the experiences of people with food hypersensitivities (FHS) when eating out to gain a deeper understanding of how people with FHS navigate potential barriers and evaluate associated risks.

Food hypersensitivity
Food hypersensitivity can be divided into food allergy and non-allergic food hypersensitivity (formerly referred to as food intolerance). Food allergy can be sub-divided into IgE mediated food allergy (for example to milk, eggs, and peanuts) and Non-IgE mediated food allergy (for example coeliac disease that does not have an immunological basis).

The most recently published estimates from the FSA's Food and You 2 survey suggests that 800,000 people in the UK are living with a clinically diagnosed food allergy, 300,000 have coeliac disease and a further 1.2 million are living with food intolerance and other FHS conditions.

Whilst there are clear risks to physical health, there can also be psychological, social and financial impacts of living with FHS. One setting that has particularly been linked to incidents of accidental allergen ingestion, and associated stress and anxiety for food hypersensitive citizens, is eating outside the home. A systematic review concluded that eating out in cafés and restaurants account for 21-31% of accidental allergen ingestion with a further 13-23% linked to other eating out environments (footnote 2).

Prompt and accurate communication between food providers and their customers is key to FHS consumers being able to manage risk. This project engaged with FHS citizens and partner

organisations and experts representing the FHS community to co-develop and carry out this pilot research. Citizen scientists collected first-hand observations and reflections around eating food prepared out of home.

The study's aims were:

- to collect key information from FHS consumers about how they assess allergen risk when eating food prepared outside the home.
- to assess the future feasibility of engaging those with FHS as citizen scientists.

Citizen scientists were recruited (n=121) with the help of project partners and worked with researchers to co-design research materials. A subgroup (n=66) then used the co-designed collection tools to record their experiences of eating out, capturing 241 different eating out experiences and uploading photos where relevant.

Project collaborators and partners included charities (Anaphylaxis Campaign, Allergy UK, Coeliac UK, Allergy Action and the Natasha Allergy Research), as well as clinical and industry representatives. All partners were involved as advisors, and assisted with recruitment, along with others that advocate on behalf of FHS communities.

This project spans several FSA ARIs, but primarily relates to research priority one (assuring food and feed safety and standards) and informs the question: What is the impact of food hypersensitivity (including allergies and intolerance) and how can we reduce it?

Citizen scientist profile and reported learning outcomes

Across the project, 121 FHS citizen scientists took part. A range of allergens were being avoided by participants, such as cereals (62%), cow's milk (27%), and peanuts (26%). The nature and severity of reported reactions to allergens also varied. Anaphylaxis, the most severe and life-threatening response to allergen exposure was reported by a fifth of the citizen scientists. Other common reactions to allergens reported by around 50% of respondents were stomach cramps, digestive problems, and tiredness or diarrhoea.

Citizens reported benefiting from participating in this project in different ways, including:

- feeling their contribution was valued and had impact:
- "I also liked the fact that some of the things that we suggested became part of the questionnaire. I know something I suggested was there and a couple of other people said things that I then saw in the questionnaire when it was finalised. It was nice to feel that we weren't rubberstamping something but that we were an active part of it, which I liked."
- gaining knowledge through reviewing anonymised data collected, allowing reflection in group settings and individually:
- ".. it made me more aware of what the restaurants offer, but also I probably didn't realise how much I rely on my own knowledge of what goes into dishes, and being able to make an informed decision."
- feeling a sense of community through interacting with and listening to the experiences of their peer citizen scientists, reflecting on how similar or different those were from their own:
- "It was really interesting to hear other people's views of their experiences and what they expect and what they don't want, what they do want and I was like, 'I'm not like that, I think something different'"

Preliminary findings

Engagement was key in making citizen scientists feel actively part of the research project. This was achieved through fortnightly newsletters and planned events, such as workshops, to discuss research findings. These engagement opportunities promoted two-way communication from the

beginning (creation of materials) to the end of the project (dissemination of results).

Preliminary findings indicate that online information provided by eating establishments had a key role in supporting people with FHS in planning their eating out experience prior to arriving at the venue.

Next steps

Detailed findings will be reported in articles submitted to academic journals. A full project report will follow on the FSA website once academic publications are complete.

Key allergy charities will provide opportunities to share outputs/findings of this work through blogs, policy briefs and at relevant workshops and conferences. They will also be shared through the media channels of the University of Bath, University of Manchester and their supporting collaborators and partners.

Food allergy awareness champions: Towards improving food safety standards in online food procurement for people with food hypersensitivity

Dr Tassos Koidis, Queen's University Belfast (QUB)

This pilot study aimed to develop a better understanding of the practices, and behaviors of people with food hypersensitivities when buying food online, and to use accredited methods to determine the presence of certain allergens in selected samples of food procured by participants.

Through participating and reflecting on their own practices and those of other citizen scientists, it was anticipated that participants would have the opportunity to increase their knowledge, understanding and awareness about ordering online. In this way citizen scientists could gain additional insight around their challenges in accessing information and navigating online spaces themselves or when other people with FHS do so.

There have been changes more recently in how people commonly acquire and consume food at home. The practice of ordering online food delivery including ready to consume meals, drinks, and snacks has increased immensely. The COVID-19 pandemic has likely been a factor in this change in practice as it's now the case that one in four consumers thinks about using meal delivery services on a regular basis. (footnote 3)

As procedures and practices of allergen management by both consumers and businesses are mostly unmapped across this evolving landscape and with a lack of empirical evidence, studies are needed to answer emerging questions regarding food standards and allergen controls.

The aims of this project were:

- to improve understanding and knowledge of the behaviours of FHS citizen scientists buying ready to eat (takeaway and delivered) food online.
- to learn more about the visible procedures and practices of individual food businesses offering online food delivery.
- to use accredited methods to determine the presence of certain allergens in selected samples of food procured by participants.

The project partners and collaborators were consumers (acting as both citizen scientists and consumers), working with researchers from QUB and University honorary Professor Michael Walker, an expert in the bioanalysis of food allergens. Partners to the project were Coeliac UK and Hazel Gowland of Allergy Action. Professional laboratory ROMER Labs UK carried out testing of the collected meals.

This project spans several FSA ARIs, but primarily relates to research priority one (assuring food and feed safety and standards) and informs the question: What is the impact of food hypersensitivity (including allergies and intolerance) and how can we reduce it?

Citizen scientist profile and reported learnings

Of 297 citizen scientists initially recruited, 36 were males (12%) and 259 females (87%), aged from 16 to 75+, with the majority aged 35-44, (30% with only one individual between 16-18 years old). Most participants lived in England (73%), followed by Scotland (11%), Wales (5%) and Northern Ireland (4%).

Most citizen scientists reported having FHS (94%) or caring for someone who did (6%). Almost a quarter (24%) of citizen scientists with FHS, were also caring for someone with FHS. A range of allergens were reported, most commonly cereals containing gluten (36%), but also tree nuts (12%), milk (12%) and peanuts (11%). A high proportion of citizen scientists (79%) reported a medically diagnosed condition, suggesting recruitment efforts meet the right demographic for this study.

The project struggled to maintain long term engagement with citizen scientists and so feedback about the benefits of the project to citizen scientists is limited. The feedback that the project did receive, suggested that the research was viewed as a validation of the importance of the issues individuals with food hypersensitivities face.

Preliminary findings

In general, respondents expressed more trust in nationwide food chains due to their perceived resources, updated information, menu consistency and/or accreditation by a UK allergy charity, such as Allergy UK or Coeliac UK.

The citizen scientists revealed some of their behaviours to minimise the risk of contamination including

- eating food alone, before or after the family or work meal
- physically separating gluten-containing from non-gluten-containing foods at the table
- double checking the food order and the labels provided
- following good food hygiene guidelines
- using their own senses.

Furthermore, there were some indications that older FHS citizens may perceive the risk of ordering online differently from younger age groups.

Next steps

The full project report will be published on the FSA website following academic journal publication. The research team plan to further develop skills in citizen science methodology and seek opportunities to apply it in other research projects conducted at QUB.

Exploring the chopping board microbiome

Dr Alan Goddard, **Aston University** & Rachel Pateman, **York University**

This pilot project sought to investigate microbiological samples from chopping boards from traditionally hard-to-access communities; underrepresented communities (minority ethnic or ME communities, and multioccupancy households) in the West Midlands.

Two fifths (40%) of outbreaks of foodborne infections in Europe occur at home (footnote 4) and home chopping boards are a key site of microbial contamination (footnote 5). Although studied previously, most investigations into chopping board use, and the effects on the associated microbiome, were conducted under the supervision of researchers, potentially changing participant behaviour. Foodborne microbes that are antibiotic resistant pose a particular challenge due to their potential ease of spread.

Antimicrobial resistance

Antimicrobial resistance (AMR) is the insusceptibility of microorganisms to substances designed to kill them or halt their growth.

AMR is relevant to food because of the potential for AMR to be transmitted to consumers via food. This can occur via 3 main routes, namely “1) the consumption of contaminated food 2) contact between humans and treated animals or 3) environmental contamination”, as summarised by Hudson et al. (2017, p.136).
These routes are not distinct because horizontal gene transfer (HGT) can readily permit the transmission of resistance between microorganisms.
Antimicrobial resistance presents a major health risk when AMR bacteria cause illness in humans and animals.

Whilst citizen science projects tend to engage “easy-to-reach” groups (footnote 6), the researchers (based at Aston University) capitalised on the demographic diversity of their student body (See Aston University access and participation plan) to access underrepresented communities (minority ethnic or ME communities, and multioccupancy households). The project recruited citizen scientists studying at Aston (who already had basic competency and interest in microbiology) who acted as ambassadors, recruiting other citizen scientists in their homes and communities.

Citizen scientists collected samples from chopping boards in their own homes using swabbing kits and following instructions they had previously co-developed with researchers. All participants were given the opportunity to undertake basic microbiological analyses in the laboratory. As such, citizen scientists were able to learn more about the scientific process (from data collection and microbiological analysis, to report writing), and in doing so also had the opportunity to increase their understanding of the microbiology of food.

The aims of this research were to:

1. Enumerate and identify the bacteria present and determine their antimicrobial resistance (AMR) profiles, providing opportunities for ambassadors and citizens to perform lab research.
2. With ambassadors and citizens, co-design and disseminate educational materials on food hygiene tailored to our target communities and based on the findings of the study.

This project spans several FSA ARIs, but primarily relates to research priority four (Addressing global grand challenges) and informs the question: How can the FSA improve the evidence base concerning Antimicrobial Resistance (AMR) and food??

Citizen scientist profile and reported learnings

Thirty-nine citizen scientists were recruited from the university student population as ambassadors. The majority were from ME backgrounds (81%) and lived in their family homes (98%). Ambassadors recruited five additional citizen scientists from their personal contacts and households.
Ambassadors reported that they had: gained a better understanding of the AMR topic than they did in lectures; really valued the extra practical experience they gained through the lab work; felt

that the knowledge and skills they gained were transferable to other parts of their degree studies.

Preliminary findings

A total of 25 chopping boards were sampled to evaluate the presence of key foodborne disease-causing bacteria and bacteria originating from the human gut or skin. Gut bacteria were present on 11/25 chopping boards and skin bacteria on 13/25. Six chopping boards had both, and seven harbored neither skin nor gut bacteria. Due to delays in obtaining ethical approval to run the study, there was not time to complete the AMR analysis of the samples.

The number of samples collected was smaller than expected and did not allow for meaningful conclusions to be made, or for the co-development of educational materials on food hygiene as planned. However, the research has revealed potential trends in behaviour in chopping board hygiene in relation to perceived contamination risks, that warrant future investigation.

Next steps

A full project report is available on the FSA website and a paper will also be submitted to the 'Access Microbiology' journal. The researchers also aim to present the project at a microbiology conference where there is a focus on public engagement and outreach or education and the methodologies involved.

Citizen science and antimicrobial resistance

Dr Sarah West, University of York

This pilot project sought to collect data about food handling practices of home-grown produce and improve the understanding of transmission pathways of antimicrobial resistant (AMR) bacteria. The project also investigated the impact of involvement in the study on citizens' knowledge and understanding of food safety and AMR. The project team was from the University of York (lead), University of Reading, Royal Veterinary College, Garden Organic and a York-based growing group. This gave citizen science expertise (University of York and Garden Organic), microbiology and food systems expertise (University of Reading and Royal Veterinary College) and growing expertise (Garden Organic and York growers).

Knowledge of AMR in home-grown produce, and relevant consumer behaviours, is not well researched and knowledge of this major global health challenge remains relatively low. One potential source of bacteria on homegrown produce is manure, and whilst there is existing FSA guidance, its use is not regulated. Even when following the advice, it is unclear whether there may still be risk (footnote 7), (footnote 8).

Growers with allotments and gardens were recruited to investigate samples of salad leaves to find out if selected target bacteria were present on their surface. If these bacteria were detected, the bacterial cultures were tested for antimicrobial resistance.

Citizen scientists were involved at all stages of the investigation and worked with researchers to co-develop the swab questionnaire and data analysis process. Researchers hosted regular online question and answer sessions, introducing participants to different topics (antibiotic resistance, microbiology and food systems) and allowed them to engage with both invited experts and members of the research team.

The specific aims of this project were to:

1. investigate the level of awareness, and to subsequently raise levels of awareness about AMR and food safety.
2. collect data on the presence of AMR on produce grown by the public.

This project informs research priority four (Addressing global grand challenges) and informs the question: How can the FSA improve the evidence base concerning Antimicrobial Resistance (AMR) and food??

Citizen scientist profile and reported learnings

In total, 124 citizen scientists took part in the project, with the majority (66%) taking part in data collection and swabbing for bacteria (much higher than the 20% aim).

Research has shown that people from minority ethnic groups and from lower socio-economic backgrounds are under-represented in citizen science projects (footnote 9), (footnote 10). Although the project team tried to reach growers from diverse backgrounds by working with community growing organisations in places with diverse populations, citizen scientists were predominantly from a white ethnic background (89-97%, depending on project phase).

A subset of citizen scientists (33/124) responded to the post project survey. The majority gave positive feedback, with 86% reporting that they would be happy to be contacted about future AMR projects run by the research team. Over two thirds (70%) said they had learned something by participating, not only about project content (AMR), but also about scientific processes, for example:

“I have learnt lots about AMR both through the project and from other sources. I also feel that the subject can seem quite frightening, but the project has made me feel that with more research there are practices that could be implemented that could limit the extent of the problem.”

Preliminary findings

The project assessed the AMR presence in homegrown produce (salad leaves) both before and after the preparation for consumption, in 127 paired samples.
Initial findings indicate the presence of target bacteria in 48 of the 254 samples taken, including *E. coli* and to a lesser extent *Listeria* and *salmonella*. The project team found that the majority (92%) of the bacteria were resistant or multi-resistant to the antimicrobial agents tested.

Next steps

A full project report is available on the FSA website and publication of a joint paper (in the Access Microbiology journal) is planned with members of the ‘Exploring the Chopping Board Microbiome’ project, reflecting on use of citizen science methods to investigate AMR in private settings. Learning from this project (e.g. around the use of the noticeboard platform, Padlet) have already informed other citizen science projects worked on by the research team.

Using citizen science to explore plant breeding and investigate food-chain transparency for novel breeding methods

Dr Gulbanu Kaptan, University of Leeds

This pilot project sought to use citizen science methods to explore and improve participants’ knowledge of the use of plant breeding technologies in the food chain, and consumers’ expectations and needs regarding a transparent food system.

Plant breeding

Plant breeding has been practiced for millennia to produce genetically improved species; for example, to make precursors of today’s well-known crops such as maize, wheat and apples, more resistant to diseases, higher yielding, and more nutritious.

Gene editing is a relatively new laboratory technique that results in genetic changes equivalent to those used in traditional plant breeding. However, it is a more advanced technology than traditional breeding and other genetic modification. Both the regulatory frameworks and public knowledge and awareness of these novel techniques are not well studied.

Citizen scientists firstly completed a questionnaire to assess their existing, baseline knowledge on plant breeding, before participation in the design and data collection stages of the research. Citizen scientists also took part in interactive training, conducting online searches on the variety of information on the packages of fresh fruits and vegetables, and by reporting their findings back to the project team.

The project aimed to improve participants' knowledge on plant breeding and novel breeding methods by applying a citizen science approach, and to broaden the understanding of participants' needs and expectations regarding a transparent food system that involves the implementation of novel technologies.

The project partners and stakeholders were citizen scientists acting as citizens and consumers, collaborating researchers (from Leeds University Business School (LUBS) Aberystwyth University) and partners to the project (British Society of Plant Breeders (BSPD)).

This project spans several FSA ARIs, but primarily relates to research priority one (assuring food and feed safety and standards) and informs the question: What is the impact and risk of novel and non-traditional foods, additives, and processes on the food system, including on consumer confidence? ?

Citizen scientist profile and reported learnings

In total, 69 citizen scientists were recruited. Around two thirds (48/69) were females and a similar proportion identified as white/white British (46). The majority took part in data collection stages (59).

Feedback from each stage of the study was collected during focus groups, with participants reporting a positive experience. Stating the educational exercises, short videos prepared by the team of researchers and the materials shared were very helpful in improving their knowledge about both traditional and novel plant breeding methods and the regulatory framework. For example:

"…because there was active thinking involved in these exercises in terms of like, how am I thinking differently about this now that I've been educated on it compared to before? I think that definitely helped me realise a lot of things that I hadn't known first of all."

Preliminary findings

Early indications from focus groups suggested that citizens gained an improved knowledge about both novel and traditional breeding methods. This was measured via pre- and post-participation surveys which found that at the start of the project, around a quarter (23%) of citizen scientists reported having no knowledge on this topic.

At the end of the research nearly all participants reported improved knowledge about plant science (94%) and about how fruits and vegetables were grown (93%), and when asked most respondents were able to provide some accurate information about both traditional and novel plant breeding methods (footnote 11). About two thirds (63%) of participants reported that they trusted UK regulatory agencies, such as the FSA, to ensure that the fruits and vegetables which consumers buy are safe. However 42% felt that the food supply chain in the UK was not transparent in terms of how food is grown. About 3/4 (79%) thought that fruits and vegetables produced with novel technologies should be labelled, even if there was a public register of

approved gene edited foods. Focus group discussions also highlighted trust in regulatory agencies, but found different views around transparency and labelling, with some participants not seeing a need to label gene-edited foods as such, if they had been confirmed as safe to eat by a trusted organisation.

Next steps

Detailed findings will be reported in articles submitted to academic journals. A full project report will follow on the FSA website once academic publications are complete.

Finding the right formula – establishing the feasibility of doing science in the home to assess the safety of Powdered Infant Formula preparation

Dr Aimee Grant, Swansea University Centre for Lactation, Infant Feeding and Translational Research (LIFT).

This was a collaborative community science pilot project developed between parents and researchers that aimed to explore the safety of powdered infant formula (PIF) preparation processes and to assess the feasibility of collecting relevant data using citizen science methodology. The project sought to improve understanding around the knowledge and practices of parents and caregivers when preparing PIF, and to better understand the barriers and facilitators to safer infant feeding.

When prepared incorrectly, infant formula (IF) can pose a food safety risk and cause gastrointestinal infections, which result in over 3,200 hospital admissions per year and 10,600 GP appointments in the UK alone. (footnote 12) (footnote 13) Ninety five percent of British children will have consumed IF by the time they are nine months old. The majority use PIF making this a significant food challenge for UK public health. Despite the importance of this topic, limited research has been undertaken in “real world” conditions.

Parents and carers who used infant formula were recruited as citizen scientists and contributed to the development of the study design, data collection and analysis. The study collected data from parents in the home using a thermometer and standardised instructions to measure the temperature of the water when preparing PIF (using either kettles or formula preparation machines). Data was also collected using a research diary asking parents about their usual preparation practices to explore the feasibility of preparing formula according to NHS guidance. A smaller subgroup of five community analysts collaborated in the data analysis process.

This pilot project aimed to:

1. Generate new knowledge about practices and behaviours when preparing PIF.
2. To increase knowledge and/or experience of the scientific process amongst citizen scientists.
3. Test the feasibility of data collection tools and processes to inform a future, larger-scale, study

Partners in the project were First Steps Nutrition Trust Director, Dr Vicky Sibson, who has expertise on food safety relating to PIF; and Professor Amy Brown, Director of the Centre for Lactation, Infant Feeding and Translational Research (LIFT), who led on facilitating impact. The project team would like to acknowledge input from expert advisors who collaborated on the project, including: Jody Mellor, a formula feeding parent with experience of tube-feeding PIF, Phyll Buchanan, a mother supporter, tutor and supervisor for the Breastfeeding Network, who regularly advises on safe preparation of PIF, and Sharon Breward, Infant Feeding Co-ordinator for Betsi Cadwaldr University Health Board and an Internationally Board Certified Lactation Consultant (IBCLC).

This project spans several FSA ARIs, but primarily relates to research priority two (Understanding consumers and our wider society) and informs the question: What role does consumer and Food Business Operator behaviour and perception play in ensuring food safety and standards??

Citizen scientist profile and reported learnings

A total of 151 community scientists were recruited: 143 (95%) were mothers and 8 (5%) were fathers (no carers took part). The mean age (of those who provided this information) was 33 years, half held a postgraduate qualification and four considered themselves to be disabled. Over half (58%) were first time parents and the mean age of the youngest (or only) baby was 7 months. The five community scientists who took part in data analysis sub-group were all women.

The majority of the 151 community scientists viewed their participation in the project as either very positive (71%) or quite positive (21%). A key theme from open text responses was around the experience being interesting, enjoyable or empowering for participants, for example.

"Interested. Formula feeding was confusing at first and there is a lot of conflicting advice around. I'm pleased to contribute to a study about this topic"

Some (17) participants noted that the study had drawn their attention to the risks involved in PIF use, and, as such, reported being more concerned, or less confident, about safely preparing PIF.

"I'm now confused about the scoop and whether I should clean and sterilise it. It has impacted my confidence"

Three of these 17 parents explicitly noted that taking part in the study had made them revise their PIF preparation practices to make them safer (e.g. preparing PIF sooner after the kettle had boiled as they had identified that their kettle was not remaining at 70°C for as long as they had expected).

Key findings

The research identified a number of risks, and barriers, to following PIF preparation guidance. For example, around 30% of parents did not always make bottles one at a time as per the NHS guidance. Commonly reported barriers to following the NHS guidance included a lack of understanding of the risks involved in PIF preparation. Within this context, time pressures and perceived impracticality resulted in parents not following all advised steps in PIF preparation, particularly when preparing PIF at night and when outside of the home. In addition, there were indications that some methods and equipment may not reliably provide water at 70 degrees, as recommended by NHS guidance. Findings will be reported in full in subsequent publications, and will inform future research in this area.

The majority of citizen scientists (137, 93%) reported that they would be willing to take part in other citizen science projects, for example measuring the temperature every time they made a bottle up for a whole day (24 hours). Of these 21 noted that they would be interested in taking part, but acknowledged the inconvenience of taking part in an experiment over a longer period of time, for example: “the thank you payment would need to be worth it”. Overall, 27 people noted the importance of providing sufficient incentives.

Next steps

A full project report has been published on the FSA website and an article has also been published in the Journal Maternal and Child Nutrition. This work has already had a variety of impacts including revised consumer-facing guidance (to be added to NHS guidance pages), and a commitment from the Office of Products Standards and Safety to conduct a risk assessment and testing of formula preparation machines.

Future academic articles are planned focusing on the citizen science methods employed across the whole project, and findings from an in-depth qualitative analysis and generation of study outputs undertaken with a small group of citizen scientists.

In addition, these dissemination activities are planned:

- dissemination in academic circles to peer investigators within subject and to citizen science related events and publications.
- dissemination to parents and carers utilising infographics and related communication approaches in materials via social media and as part of a discussion article in 'The Conversation' and through other opportunities for public engagement, e.g. via known journalists or through press releases.
- dissemination to relevant Government departments with an interest or remit for child public health or relevant findings from the full report, including Office for Product Safety and Standards, Department of Health and Social Care (including Office for Health Improvement and Disparities), Food Safety Authority of Ireland, Food Standards Scotland, Public Health Agency Northern Ireland and Welsh Government.
- engaging in discussions about further investigation of the efficacy of equipment and effectiveness of real-world practices used in making up PIF and potential avenues for research collaboration.

Operational Learnings from the Programme

Two aims of the programme were to: facilitate the use of citizen science methods, and build capability, in the research community and assess the utility of the citizen science approach in exploring food standards challenges. For both of these aims it is key to reflect on what has been learnt from this work.

The main areas where operational learning points emerged relate to recruitment, engagement, data sharing, ethical assurance and working with FSA as a regulator.

Recruitment

Recruitment for some projects was a challenge. In instances where projects had pre-existing links to community groups and charities, researchers were more able to attract a range of citizens within their target groups – such as new parents, home growers and FHS consumers. Projects found input from partner organisations, community experts or already recruited citizen scientists helpful in the development of recruitment materials and identification of communication channels. In some projects, recruitment was through university and researcher connections; this was advantageous in the short timelines of these pilot projects (but did not result in representative diversity amongst citizen scientists recruited).

Considerations for future projects

- recruitment can be challenging and appropriate time should be allowed for this in project planning.
- working with partners and community organisations, and engaging citizens early, can provide communication channels and expertise to help reach target groups.
- social media channels of collaborating partners and other stakeholders of community experts were particularly effective routes to recruit citizen scientists.

Engagement

The volume and depth of engagement from citizen scientists differed between projects. Citizen scientists were also able to participate to different extents within their projects. To ensure mutual

benefits, and that citizen scientists gain something from their participation, projects need to ensure potential learnings are open to all.

Retention of citizen scientists in projects appeared to be more successful in projects which had a steady series of planned/scheduled events, activities and regular communications. Citizen scientists in several projects suggested that more face-to-face interactions, meetings or workshop sessions would be valuable for improving engagement in the future. (It should be noted that projects were planned during COVID-19 restrictions so investigators were cautious about relying on in person methods.)

Considerations for future projects:

- platforms for engagement and knowledge sharing need to be chosen carefully, ideally with feedback from citizen scientists. Familiarity and usability are important.
- once citizen scientists join a particular project, robust structures, planning and processes are essential to ensure all citizen scientists are enabled to participate. Structure can help enable citizens to opt for as much or as little engagement as they choose. Providing a defined menu of activities can facilitate this.
- co-development of codes of conduct for group work, discussions and message boards is best practice and provides a useful framework to guide interactions. Researchers should also facilitate, rather than lead discussions, and provide all citizen scientists space and opportunity to contribute.
- regular communications and engagement activities can help retention and provides opportunities for differing levels of engagement.
- video conferencing can be used effectively where participants are geographically spread out or have limited time to attend in-person meetings.
- virtual noticeboard tools, (for example, Padlet, Miro) can be used as a virtual information hub alongside regular newsletters to provide updates and prompts to view the board.
- citizen scientists should always be reimbursed for ‘out of pocket’ costs and provided with the use of equipment and materials, as required. Providing financial compensation for time is however often debated, under the view that citizen scientists ‘volunteer’, and are motivated principally by a desire to learn, to contribute to a cause, and/or to experience personal enjoyment/leisure (footnote 14). In projects focusing on underrepresented communities or vulnerable groups, payment for time may however be essential to enable participation. Structures in place that easily allow for payment or ‘payment in kind’ may facilitate increased levels of engagement. (footnote 15)

Data Sharing

When projects are complete and in keeping with the principles of citizen science, free access to data (appropriately anonymised) will be provided through data repositories (footnote 16). In addition to open data sharing, formal project reports will detail the projects background and methods, their findings and conclusions.

In programme workshop discussions, researchers commented on the importance of how data was shared. Citizen scientists may not have familiarity with the statistics or software that are used to collate and interrogate data. Therefore, where possible, easy to use interfaces (requiring little to no statistical training) will be used to make data more accessible to citizen scientists.

Considerations for future projects

- investigate local open data repositories early in the research planning process.
- run capacity building and explanatory sessions for citizens in how the experiment/study parameters affect fair and accurate interpretation of data generated.

- carefully consider software which will make data use and interrogation more straightforward, with cross tabulation or dashboard features.

Ethical Assurance

Citizen science methods are increasingly being used in research, however, studies using these methods continue to represent a small proportion of research conducted. Departmental ethics committees, outside of the medical sciences (where patient/public involvement is standard), may have limited experience of evaluating studies using a citizen science approach. By their nature, citizen science projects will often require input from the public before research aims, design and protocols are able to be finalised. As such it is often necessary to view the ethical approval process as multistage, to account for this collaboration and co-development. The iterative approach to ethical approval needed for the project, often lead to delays in project timelines.

During programme meeting discussions, researchers shared a number of approaches that they had taken to aid the progress of their projects, and support the ethical approvals process. Some of these are shared below.

Considerations for future projects

- agree multi-stage ethics process with administrators, to allow for collaboration with citizen scientists to co-develop research questions, protocols and methods alongside researchers and other stakeholders.
- include details of the process for setting up and agreeing codes of behaviour with citizen scientists, particularly in group work and for social media use, and outline how inappropriate behaviour will be dealt with.
- for group work and social media or message boards, describe how a moderated system would function, what resources will be needed, and other safeguards for participants.
- research the capabilities and risks of any software/social media platforms that are intended to be used and ensure limitations and function are adequately communicated.

Working with the FSA as a regulator

Applications to the funding call were assessed by an independent review panel, comprising recognised experts in relevant areas of research and/or citizen science methodology. The FSAs Chief Scientific Advisor – Professor Robin May – served an advisory role, providing input in terms of the relevance of project proposals to the FSA ARIs. Projects were however awarded funding on the basis of the gradings of the independent review panel.

FSA research is usually commissioned with input from relevant policy teams, and with clear links to strategic priorities and evidence needs. Funding research via a joint call with UKRI, necessitated a more independent approach that couldn’t enable this level of consideration, but did result in research in areas not typically explored by the FSA, generating new knowledge.

Unlike a traditional funding council or charitable funding body, the FSA has statutory obligations around food safety and a duty of care to consumers. Any identification of risk to consumers during the research process therefore needs to be considered and managed appropriately. Ethical approval processes focus on risks to study participants, and will not identify the potential impact of any research findings that could be relevant to regulatory obligations of a statutory body. As such, prior to fieldwork, appropriate mechanisms were needed to ensure effective communication of any identified risks (such as the identification of unexpected allergens). This was achieved effectively through engagement with project leads and relevant FSA teams, however this created additional, and unanticipated, requirements for some projects, adding to the complexity of the project design or to the complexity of communicating findings.

In the ‘Food Allergy Awareness Champions’ project, meals were tested for the presence of allergens. Identification of an allergen is clearly a food safety risk to consumers. In line with FSA statutory requirements, the research protocol was redesigned to reduce risk of citizens scientists’ exposure to meals purchased. The risk of consumers outside the study purchasing a hypothetically contaminated meal were also managed; researchers would notify the relevant FSA official immediately should an allergen be found (rather than this being communicated in a subsequent publication after study completion).

In the ‘Finding the Right Formula’ project, citizen scientists and researchers found indications that some methods to make up PIF using different water heating equipment may be unreliable. The FSA liaison for this project facilitated discussions between the FSA, external stakeholders and the project team, so that multiagency views and priorities were considered immediately (prior to publication of results) and subsequent potential research and policy considerations could be identified.

In both projects the FSA’s dual role as a regulatory body, and a funder in continued dialogue with projects, ensured that the issues were identified and addressed in real time.

To make research findings more accessible for policy makers, and the general public, projects were required to submit a full research report, for publication (on the FSA website). This is best practice for government funded research, and standard practise at the FSA, and as such, was stipulated in the funding call requirements. However, other research funders may not usually require this reporting, with academic dissemination being the main route to raising awareness of the research and achieving impact. As such this was an additional requirement on projects.

Conclusion

The programme addressed its primary aims, as per the below.

Aim 1: Assess the utility of the citizen science approach in exploring FSA research priorities across multiple areas of research interest.

The six projects spanned multiple research areas addressing six of the FSA research areas of interest. Citizen science facilitated data collection in a number of environments (e.g. in the home, ordering online, and eating out), with a variety of cohorts (e.g. FHS consumers, parent/carers of babies, and home growers). All of the projects have informed what we know about the application of the citizen science approach to FSA research interests. Some projects experienced challenges with recruitment, retention, and ethical approval timelines. Overall, the programme has demonstrated that the method has the potential to reveal new insights in food safety.

Aim 2: Facilitate the use of citizen science methods, and built capability, in the food policy research community.

As part of the programme, UKRI and FSA hosted a number of events aimed at building capability. Throughout the course of project funding, programme meetings were held for project teams to share learnings and provide a forum for discussion about the challenges and successes experienced by projects. In addition, UKRI and FSA hosted the Citizen Science for Policy and Practice conference in October 2022, where anyone with an interest in citizen science could learn more on what citizen science is, and what opportunities it offers for policymakers, funders and researchers. With international speakers and a variety of projects showcased (including the 6 funded projects), the event also provided networking opportunities and workshop discussions on a variety of subjects, such as ethical working and valuing citizen scientists. The event was popular with over 200 attendees. Capability was also built through project level collaboration with partner organisations, which raised awareness of the role of citizen scientists in research and how citizen science methods can be utilised for policy relevant research.

Aim 3: Expand the range of people from outside of academia involved in food policy research.

The projects collaborated with over 600 citizen scientists, researchers across nine Universities, 12 partner organisations, four community or specialist advisors and two business representative bodies overall. Whilst it is not possible to know how different these collaborations would have been using other research methods, the use of citizen science approaches are likely to have enhanced levels of public engagement.

Aim 4: Provide learning opportunities to the members of the public involved as citizen scientists, including involving citizens in the research design process where possible.

Across all projects, citizens who gave feedback reported an increased knowledge of scientific methods and/or processes. Additional benefits varied by project, and included:

- increasing their knowledge and understanding of the research areas investigated.
- developing insight by interacting with one another and reflecting on their own practices and those of others.
- feeling they had a made a valuable contribution to a research area of importance to them.

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2. A. Versluis, A. C. Knulst, A. G. Kruizinga, A. Michelsen, G. F. Houben, J. L. Baumert, H. van Os-Medendorp 2015, Frequency, severity and causes of unexpected allergic reactions to food: a systematic literature review Clinical & Experimental Allergy, 45 (2) pp 347-367, DOI: https://doi.org/10.1111/cea.12328

3. Global Food Delivery Trends 2018 vs. 2021. Understanding food delivery growth across the US, UK, Canada and Australia. Edison Trends (2021). https://trends.edison.tech/research/global-food-delivery-2021.html Accessed on 13 March 2023.

4. EFSA and ECDC (European Food Safety Authority and European Centre for Disease Prevention and Control), 2019. The European Union One Health 2018 Zoonoses Report. EFSA Journal 2019;17(12):5926, 276 pp. DOI: https://doi.org/10.2903/j.efsa.2019.5926

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6. Adam G. Hart , David Adcock, Matthew Barr, Stuart Church, Tamara Clegg, Samuel Copland, Kris De Meyer, Ria Dunkley, Rachel M. Pateman, Ralph Underhill, Kayleigh Wyles, Michael J. O. Pocock, 2022, Meeting Report: Understanding Engagement, Marketing, and Motivation to Benefit Recruitment and Retention in Citizen Science Citizen Science Theory, Practice, 7(1), pp.5 DOI: https://doi.org/10.5334/cstp.436

7. Keenum, I., Williams, R.K., Ray, P. et al. Combined effects of composting and antibiotic administration on cattle manure–borne antibiotic resistance genes. Microbiome 9, 81

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9. Pateman, R., Dyke, A. and West, S., 2021. The Diversity of Participants in Environmental Citizen Science. Citizen Science: Theory and Practice, 6(1), p.9. DOI: http://doi.org/10.5334/cstp.369

10. West, S., Dyke, A. and Pateman, R., 2021. Variations in the Motivations of Environmental Citizen Scientists. Citizen Science: Theory and Practice, 6(1), p.14. DOI: http://doi.org/10.5334/cstp.370

11. In an open-ended post-engagement survey question, we asked citizen scientists to briefly define gene-editing and CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats, which are the hallmark of a bacterial defense system that forms the basis for CRISPR-Cas9 genome editing technology)

12. Renfrew (2012). Preventing Disease and Saving Resources. UNICEF. p.43 https://www.unicef.org.uk/wp-content/uploads/sites/2/2012/11/Preventing_disease_saving_resources.pdf

13. McAndrew et al. Infant Feeding Survey. UKDA 7281 https://sp.ukdataservice.ac.uk/doc/7281/mrdoc/pdf/7281_ifs-uk-2010_report.pdf

14. Recruiting, paying, and evaluating the experiences of civic scientists studying urban park usage during the beginning of the COVID-19 pandemic, Front. Sustain. Cities, Volume 4 - 2022 | https://doi.org/10.3389/frsc.2022.709968

15. A review for improvements in patient/public involvement in the four nations is underway, which may provide models for reimbursement and other payment structures for citizen scientists.

16. The Finding the Formula Project will ensure that in their case any sharing of data will adheres to the World Health Organisation International Code of Marketing of Breast-milk Substitutes. We believe that parents should have transparent information free from industry involvement