Adopting a citizen science approach in translational experimental medicine research in non-alcoholic fatty liver disease: A study protocol

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Method Article

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Abstract

Background

Citizen science approaches are widely and successfully used in biological, environmental, and ecological sciences; however, they are rarely applied in other domains, such as translational health research, notably in the field of liver disease and metabolism. This citizen science study aims to explore the application of the citizen science approach in a translational experimental medicine experiment on non-alcoholic fatty liver disease (NAFLD) and a 12-week lifestyle and weight loss program. In this methodological paper we describe the process of involving citizen scientists in the study.

Methods

In his exploratory study, we will recruit a convenience sample of thirty-one participants (with and without NAFLD) and a half-dozen citizen scientists (members of public). Citizen scientists will work alongside clinical and non-clinical researchers in a translational experimental medicine study on NAFLD. Citizen scientists will be involved in the co-design and/or review of data collection tools (e.g., semi-structured open-ended questionnaire surveys and semi-structured wellbeing diaries completed by the participants), co-analysis of data on participants' experiences and motivations, co-drafting of research findings and papers, and suggesting policy recommendations. Citizen scientists will be provided training in research tasks undertaken by them. Citizen scientists will be either co-authors or their names will be mentioned in the acknowledgements in research paper(s) based on the level of research contributions.

Discussion

Lessons learned from implementing citizen science in this study will help better understand the advantages and disadvantages of using citizen science in the field of translational medicine research. It will also provide insights as to how citizen science can be integrated in other translational research studies.

Conclusion

Involving citizen scientists in translational medicine research is important for extending research opportunities for member of the public; however, there may be methodological challenges, which may be identified and resolved by more research studies.

Background

Citizen science refers to a research approach in which citizens (members of the public) collaborate with professional researchers / scientists to contribute significantly to scientific inquiry and science (Socientize Consortium 2013). Thereby citizens/members of public act as citizen scientists and apply their skills and knowledge to the research process; thus, research is made with, and by citizens (Irwin, 2018).
Citizen science is commonly applied in social sciences, humanities, natural sciences (Tauginienė et al. 2020), conservation, biology, digital technology (Kullenberg and Kasperowski 2016) and public health (Rosas et al. 2022). There is a growing interest in expanding the application of citizen science approaches to other fields (Borda, Gray and Downie 2019; Follett and Strezov 2015) such as the medical sciences (Petersen et al. 2020) and particularly translational research where the application of citizen science is still nascent (Carroll et al. 2021). Differences in the focus of research (e.g., nature versus patients), data collection methods (e.g., observation versus skilled medical procedures) and the ethics beyond the corresponding topics (e.g., preserving patients’ confidentiality) may explain such differences (Kullenberg & Kasperowski, 2016). However, even when the context might be more complicated, the potential benefits of using citizen science across disciplines by making research more accessible, transparent, and relevant to citizens cannot be overlooked (Heigl et al., 2020; Kaye et al., 2012; Wiggins & Wilbanks, 2019).

In health sciences, a number of terminologies have been used to describe the implementation of citizen science such as “self-quantification”, “crowdsourcing”, “participatory health”, “action research”, “patient-led research”, and “public and patient involvement (PPI)” (Borda et al., 2019; Borda et al., 2020; Eitzel et al., 2021; Heigl et al., 2020). For example, PPI is used as a way of involving citizens in research to ensure resulting products respond to the needs and preferences of the patients and public as well as the research targets (Carroll et al., 2021). PPI is extensively established in the United Kingdom (UK) where its implementation has become a requirement for obtaining research grants (NIHR, 2020). Despite many advantages and successful outcomes, PPI has been criticized for being time consuming, costly, and tokenistic (Blackburn et al. 2018). In contrast, citizen scientists’ involvement in citizen science studies is active, multistage and voluntary except reimbursement of some expenses and there are opportunities of training, learning and knowledge production (Haklay et al. 2021). Nonetheless, patients have been involved as citizen scientists in research studies (Heyen et al. 2022) but it is not always feasible to involve patients as citizen scientists because of the participants’ privacy, anonymity and ethical reasons (Groot and Abma 2022). Through this study we aim to explore the application of the citizen science approach in translational medicine research. This study is being conducted as a part of an EU funded citizen science project called STEP CHANGE, which aims to explore and exploit the potential of citizen science in terms of knowledge and innovation advancement and science and society alignment, through the development and evaluation of five citizen science initiatives (CSIs) in the fields of health, energy, and environment (https://stepchangeproject.eu/). One of these CSIs is on Non-alcoholic fatty liver disease (NAFLD) conducted in the UK, which is reported in this paper.

Research in NAFLD is important because it is a metabolic disorder (Zarghamravanbakhsh, Frenkel and Poretsky 2021) affecting about 25% of the global population (Younossi et al. 2016). The prevalence of NAFLD is about 26% in Europe (Bellentani 2017) and it is increasing in several countries (Wong et al. 2018). NAFLD is characterized by excess triacylglycerol accumulation within hepatocytes (epithelial cells of the liver), which can progress to inflammation (non-alcoholic steatohepatitis), cirrhosis and liver cancer (Ye et al. 2020). NAFLD increases the risk of liver-related and all-cause mortality (Kumar,
There are no licensed medications for NAFLD, and the management currently revolves around lifestyle and weight loss interventions (Esteban and Dinani 2020).

The aim of the CSI on NAFLD is to explore the application of the citizen science approach in translational experimental medicine in the field of the metabolic endocrinology.

Methods

Study design

This is an exploratory study that applies a citizen science approach in a translational medicine clinical experiment. The objective of the clinical experiment is to develop a better understanding of the diurnal variation (along with circadian rhythm) of liver lipid metabolism in overweight individuals under different conditions i.e. with and without NAFLD, and before and after a lifestyle and weight loss (LWL) program. The protocol for the clinical experiment has already been externally, expert-peer reviewed, by the funder and approved by relevant research ethics committee(s) and regulatory bodies (see the ethics section below). In this paper, we describe the methodological process of involving citizen scientists in the study. However, to explain the context of the study we also report some details of the clinical part of the study. The study comprises three components as follows:

Clinical investigations

Clinical investigations will be conducted in two phases involving individuals with and without NAFLD. The first (initial) phase will involve clinical investigations in the morning (M1) and evening (E1). All participants (with and without NAFLD) will participate in both initial clinical investigations (M1 and E1). At this stage, the involvement of participants without NAFLD will end while those with NALFD will join a LWL program. Upon the completion of the LWL program, participants with NAFLD will go through the second (final) phase of clinical investigations which will be again in the morning (M2) and evening (E2). After the completion of the final clinical investigations (M2 and E2), the participation of participants with NAFLD will finish, and the clinical experiment will end. This is an open-label clinical study and there will be no randomization, comparison, or a control group. To understand the metabolic phenotype in patients with NAFLD, we will use the gold-standard approaches, which we have used extensively in that past (Ref).

Lifestyle and weight loss program

All participants with NAFLD will receive a free commercially available LWL intervention. LWL interventions typically include a combination of on-line, in-person, and app-based information and guidance on dietary intake and physical activity. Commercially available weight-loss programs have been shown to result in greater weight loss (Hartmann-Boyce et al. 2014) than the similar interventions provided in healthcare settings (Jebb et al. 2011). The LWL program will be for 12 weeks (Fig. 1) and it will be provided by commercial providers convenient to and preferred by the participants.
Qualitative study

This will involve a study of the motivations, expectations and experiences of all participants (with and without NAFLD) participating in the clinical investigations and self-reflections of participants only with NAFLD on their wellbeing and progress during their participation in the LWL program (Fig. 1).

Study settings

Participants, with or without NAFLD, living in the community will attend our hospital for the clinical investigations, whereas the LWL program will be offered in the community to the participants with NAFLD only.

Recruitment and sample size of research participants We will recruit thirty-one overweight participants (seventeen with NAFLD and fourteen without NAFLD) using the convenience sampling. We will recruit participants from the Oxford Biobank (https://www.oxfordbiobank.org.uk), which is a database of more than 9000 volunteers in Oxfordshire, England who have undergone extensive metabolic phenotyping and consented to be re-approached for clinical research. Overweight individuals in the top and bottom 10th percentiles of fasting glucose and insulin will be recalled enriching for the presence of NAFLD and non-NAFLD respectively, which will then be confirmed using magnetic resonance spectroscopy. The inclusion criteria for participants include people who are overweight (BMI 25–50 kg/m$^2$) with and without NAFLD and aged between 18 and 75 years. The presence or absence of NAFLD will be confirmed with transient elastography with controlled attenuation parameter $\geq 306$ dB/ and $\leq 215$ dB/m respectively (Tavaglione et al. 2022).

Recruitment of citizen scientists

We will recruit citizen scientists from members of the public aged 18 years and above and from diverse socio-demographic backgrounds. Citizen scientists will work as volunteers in the study. For recruiting citizen scientists there is no recommended sample size, which depends on the type and context of the research study and the research activities undertaken by them. A review of citizen scientists’ involvement in public health research found a wide variation in the number of citizen scientists, from 8 to 5000 in a study (Rosas et al. 2022). In our study, we will recruit about a half-dozen of citizen scientists. The reasons being that this is an exploratory study, and we want to have a parity in the number of citizen scientists and professional researchers / scientists involved in our study (n = 5). We will therefore recruit about six citizen scientists, considering estimated dropout out of 20%. We will recruit citizen scientists using the convenience sampling (Chrisinger et al. 2018) and snowball sampling methods (Eleta et al. 2019; Trejo et al. 2021). We will advertise calls for citizen scientists on websites of the STEP CHANGE project and our research centre, send targeted emails to individuals who belong to PPI panels and obesity and diabetes patient groups, and use social media platforms (such as Twitter) to find potential candidates.

Citizen scientists will be involved for 24 months; however, they will be able to withdraw their consent and leave the study at any time without giving any reason. As citizen scientists contribute in their spare time
and on an unpaid and voluntary basis (Pocock et al. 2017), we will let them decide how much time they want to devote to the study and choose when and which research activities they want to participate in.

**Ethical issues**

**Research participants**

All participants invited to the study will receive copies of the Participant Information Sheet (PIS) and Informed Consent Form. The PIS will provide details and the exact nature of the study; what it will involve for the participant and any risks involved in taking part. The participants will be free to withdraw from the study at any time for any reason without prejudice to future care, and with no obligation to give a reason for withdrawal. The participant will be given time as much as they wish to consider the information, and the opportunity to question the investigator(s) prior to joining the study. The participant however must personally sign and date the Informed Consent Form before participating in the study.

**Citizen scientists**

Each citizen scientist will also get copies of the Citizen Scientist Information Sheet and Informed Consent Form by an e-mail. The Information Sheet will provide information about the research study, the roles and rights of citizen scientists, and potential research tasks undertaken by citizen scientists and contact details of the research team. Citizen scientists will be given ample time to read the information sheet and ask questions, if any, from the research team. Although seeking a written informed consent form citizen scientists is not very common practice in European citizen science projects (Tsinaraki and Schade 2016), each citizen scientist will be required to complete an Informed Consent Form and send it by email to a designated member of the research team.

**Data collection**

Data from participants will be collected by clinical researchers (JWT and TM) as described below:

(a) **Clinical investigations:** We will collect clinical data during the Initial and final clinical investigations using validated scales (e.g., International Physical Activity Questionnaire (Craig et al. 2003) and Pittsburgh Sleep Quality Index (Buysse et al. 1989), structured diaries (e.g., about food intake in the previous seven days). We will also collect clinical data using non-invasive procedures (e.g., DXA Scan to measure body fat) and invasive medical procedures (e.g., Subcutaneous adipose tissue and skeletal muscle biopsies and blood tests).

(b) **Participants’ motivations and expectations.** We will collect these data using semi-structured open-ended questionnaires during the initial and final clinical investigations appointments. These questionnaires will be prepared in house by the research team. Clinical researchers will administer the questionnaires and record the responses of the participants.

(c) **Participants’ reflective diaries:** Participants with NAFLD only will write, on a weekly basis, their semi-structured wellbeing diaries reflecting on their own experiences and feelings about their wellbeing,
progress and adherence to the 12-week LWL program. Participants will be provided a blank diary along with an information sheet with basic instructions. However, participants will decide how detailed they want their entries to be. Participants will be asked to return their diaries on the day of their final clinical investigations. Should they forget to hand back their diaries, they will be provided a pre-paid envelope to return their diaries by post.

**Data analysis**

Clinical data collected during initial morning and evening (E1/M1) clinical investigations will be analysed for: (a) Primary endpoint: Difference in liver de novo lipogenesis (DNL) between morning and evening investigations, (b) Secondary endpoints: Liver and global fatty acid oxidation and mobilization. In addition, the diurnal (morning and evening) patterns will be compared between participants with and without NAFLD.

Clinical data collected in the final morning and evening (E2/M2) clinical investigations will be analysed for: (a) Primary outcome: Change in the diurnal variation of liver DNL before and after the 12-week lifestyle program, (b) Secondary outcome: Liver fat fraction and liver and global fatty acid oxidation and mobilization.

All clinical data will be analysed and interpreted by clinical researchers, apart from clinical data collected on the physical activity, sleep quality index and structured diaries about food intake in the seven days prior to clinical investigations, which will be de-identified and then shared with citizen scientists for co-analysis. In addition, de-identified qualitative data on participants’ motivations, expectations, experiences and reflective diaries about the LWL program will also be co-analysed by citizen scientists and non-clinical researchers (SGSS, YBM and VK) with input from clinical researchers (JWT and TM).

Quantitative data will be analysed mainly by frequencies and descriptive statistics using either Microsoft Excel or SPSS (IBM Corp. Armonk, NY) whereas qualitative data will be analysed by inductive thematic analysis (Braun and Clarke 2006) using either Microsoft Word or NVivo® (QSR International Pty Ltd). Identified themes and subthemes will be compared, discussed, and finalized with consensus in joint meetings involving citizen scientists and scientific researchers. Both citizen scientists and scientific researchers (SGSS, YBM and VK) will identify representative quotes from de-identified participants’ experiences data, which will be finalised by consensus.

**Activities undertaken by citizen scientists**

Citizen scientists have been involved in different phases of research projects (Rosas et al. 2022), such as the project design development, data collection and analysis, research publications (Borda, Gray and Fu 2020; Heigl et al. 2020), and communication and dissemination activities (Shirk et al. 2012).

Contrary to the most frequent involvement in data collection (Bonney et al. 2009), citizen scientists in our study will not collect data, which will be done by only clinical researchers because of ethical reasons. However, citizen scientists will be invited to participate in multiple activities as shown in Fig. 2:
Synthesis and dissemination of findings

Joint meetings of citizen scientists and researchers will be held to review, finalize the major themes, and synthesise the findings. Citizen scientists will be invited to co-drafting research findings and papers, which will be reviewed and revised in joint meetings of citizen scientists and scientific researchers.

Study results will be disseminated via presentations at (inter-)national conferences, research open days and patient and public engagement events, and through journal articles. Copies of the project final report and publications will be provided to the study participants and citizen scientists on request.

Training of citizen scientists

Citizen scientists require training to contextualize their participation in the study, and discuss and manage their expectations to avoid any deception in research (Eleta et al. 2019). We will therefore survey citizen scientists’ training needs in selected research skills such as co-design and review of data collection tools (i.e., semi-structured open-ended questionnaire surveys and semi-structured wellbeing diaries), analysis of de-identified data and co-drafting of research papers. We will ask citizen scientists how, when and where they would like to attend the training. Training will be provided by professional researchers affiliated with our biomedical research centre.

Recognition and benefits of citizen scientists

To overcome the invisibility of citizen scientists’ research contributions (Kullenberg and Kasperowski 2016) and for transparent reporting of research, in our study citizen scientists will be co-authors of the research paper(s) if they meet criteria for the authorship of peer reviewed journal articles. While those citizen scientists who do not qualify as co-authors will be recognized in the acknowledgements in the research paper(s) and project reports. If a citizen scientist does not wish to be named in a research publication, an aggregate acknowledgement as “citizen scientists” will be added.

Citizen scientists benefit from their participation in research projects in a number of ways (Peter et al. 2021; Walker, Smigaj and Tani 2021). We will offer citizen scientists several benefits (Fig. 3).

Risks to citizen scientists

Citizen scientists involved in research could face health and safety risks and find research tasks difficult as overburdening and time consuming (Walker, Smigaj and Tani 2021). We do not anticipate any health and safety risks to citizen scientists in our study. The level of citizen scientists’ involvement in research tasks will be adjusted according to their availability, research skills and interests. We will explain the citizen scientists’ role and research activities in which they will be involved. We will also explore their expectations and training needs to avoid any ambiguity and deception in research (Eleta et al. 2019).

Data management and sharing

All participant / patient data including consent forms will be stored on secured computers and these data will be managed by the clinical researchers (JWT and TM). Patient data will be de-identified using unique
ID numbers, before any analysis is conducted. Participants identifiers will be securely stored on encrypted, and password protected computers accessed by only clinical researchers. The data will be retained for five years for research and publication purpose; thereafter, data will be archived according to the Data Archiving and Open Research Policy of the University of Oxford. After the end of the study, archived de-identified data could be made available to other researchers for secondary analyses under an appropriate data sharing agreement according to the data sharing policy and procedures of the University of Oxford.

Discussion

Citizen scientists (members of the public) can be co-creators, contributors, collaborators in, and even initiators of, research projects and working together with scientific researchers (Wiggins and Wilbanks 2019). However, they are most commonly involved in only data collection in research studies (Bonney et al. 2009). because of ethical reasons and patient’s privacy; and also to avoid any potential conflicts of interest and concerns about the quality of data generated by citizen scientists (Kullenberg and Kasperowski 2016) we will not involve citizen scientists in the process of data collection but they will be involved in other major research activities including the review and update of data collection tools, co-analysis of data including data processing such as coding, and annotation, and co-drafting of research papers (Borda, Gray and Fu 2020). We will also involve them in communication and dissemination of the research findings (Shirk et al. 2012), which helps in identifying the target audience, establishing the right language to use and selecting the appropriate communication channels (Rüfenacht et al. 2021).

In this way, involving citizen scientists in translational health research could help raise awareness of the public about long term medical conditions such as NAFLD in both the general population (Ghevariya et al. 2014) and populations at-risk (e.g., diabetics, obese, or overweight people) (Singh et al. 2020; Wieland et al. 2015), which is important because NAFLD can lead to liver cirrhosis, liver failure and liver cancer (Ye et al. 2020).

The involvement of citizen scientists in our translational medicine study could also promote the use of the citizen science approach in the future translational health research conducted at large translational research organizations and centres such as the National Institute for Health Research (NIHR) biomedical research centres (BRCs) in England where other approaches such as the patient and public involvement (PPI) are widely used and a standard for PPI has been developed (National Institute for Health Research 2018). In fact, the implementation of PPI in the UK is a requirement for obtaining research grants from research funding bodies like the NIHR (National Institute for Health Research 2020). PPI in research is used to ensure resulting products respond to the needs and preferences of the participants and public as well as the research targets (Carroll et al. 2021). However, a citizen science approach goes a step further by providing members of the public the opportunity to gain hands-on experience in various research tasks and activities around the research cycle. In this way, engaging citizens / members of the public in science and scientific inquiry may help improve scientific literacy (Borda, Gray and Fu 2020), reduce public
scepticism of science (Eleta et al. 2019; Follett and Strezov 2015) and make research more accessible, transparent, and relevant to citizens (Heigl et al. 2020; Kaye et al. 2012; Wiggins and Wilbanks 2019).

Limitations and challenges

There may be challenges in involving citizen scientists in research (Walker, Smigaj and Tani 2021). For example, unpredictability about the citizen scientists’ involvement in the project over the time (Eleta et al. 2019) and retaining them during the entire duration of a research study (Follett and Strezov 2015). To ensure citizen scientists’ sustained involvement in the research study, we will iteratively contact to them and get their dynamic consent, which is a consent approach that allows people to decide their ongoing participation (Prictor et al. 2020). Another challenge in citizen science studies in the dropout of citizen scientists (De Moor, Rijpma and Prats López 2019). We will tackle citizen scientists’ dropout by recruiting new ones. Additional challenges are the development of research skills (Follett and Strezov 2015) and the training of citizen scientists (Strobl et al. 2020). To tackle these issues, we will survey citizen scientists’ training needs and provide them training in-house. Another noticeable limitation could be a small number of citizen scientists involved in our study; however, their number is almost equal to the number of scientific researchers, which ensures a parity between the two types of researchers involved in our study.

Conclusion

Involving citizen scientists in translational medicine research is an important step towards extending research opportunities for member of the public; however, there are several challenges, such as the acceptance of integrating research methodologies of the two domains, i.e. citizen science and translational medicine research, which many proponents and practitioners of either domain may find challenging and unacceptable. Nonetheless, additional research studies may help to avoid the scepticism and increase the acceptance of citizen science methodologies in translational medicine research.

Declarations

ETHICS APPROVAL

This study has been reviewed and given a favourable opinion by the NHS Research Ethics Committee (IRAS Project ID 291205, REC Ref AM02; 20 December 2021), the Health Research Authority (HRA) and Health and Care Research Wales (HCRW) Approval (No. IRAS Project ID 291205; REC Ref AM02; 8 February 2022) and Medical Sciences Interdivisional Research Ethics Committee (MS IDREC) of the University of Oxford (Ref. No. R84742/RE001, 01 March 2023).

PATIENT AND PUBLIC INVOLVEMENT

The research design of the study was presented to a Public and Patient Involvement (PPI) panel associated with our research centre. Members of the PPI panel provided feedback on the research design, which was considered while final the study design.
FUNDING INFORMATION

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AUTHOR CONTRIBUTIONS

VK, JWT and SGSS led the conception and design of this study. YBM, and SGSS drafted the manuscript. JWT, VK and TM provided critical input and made important contributions to the manuscript. SGSS revised, updated and finalised the manuscript. All authors have approved the final version of the manuscript. SGSS and YMB are joint first authors.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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**Figures**
Figure 1

Study design

Source: Created by TM (a member of the research team) using https://biorender.com/

Completion of a citizen scientists' motivations survey (Month 1-2) → Review of participants' reflective diaries and questionnaire surveys (Month 3-4) → Participation in training on data analysis and ethics in research (Month 5-12) → Co-analysis of fully anonymised qualitative and quantitative data (Month 13-16)

Co-synthesis of the findings (Month 17-18) → Co-drafting of manuscript(s) (Month 20-23) → Co-writing of a policy brief and recommendations (Month 20-23) → Completion of a citizen scientists' experiences survey (Month 23-24)

Participation in the participatory evaluation of the project (Month 1-24) → Involvement in communication and dissemination activities of the project (Month 1-24)

Figure 2
Citizen scientists’ activities and timeline

Figure 3

Benefits to citizen scientists